Proposed expedition to a putative location of Sir David's Long-beaked Echidna for the purpose of conducting a rapid biological assessment

Abstract

This is a proposal for an expedition to look for the 'most wanted' animal alive. Or hopefully alive. For Sir David's Long-beaked Echidna has not been seen in 58 years, and partly as consequence it is the Zoological Society of London's top priority mammal conservation target and one of Global Wildlife Conservation's Top 25 'lost' organisms. Its most likely location, the Cyclops Mountains in Papua, are notoriously difficult to work in, and this has contributed to a dearth of data on their biodiversity. This undersampling, alongside compelling evidence that the echidna persists, and imminent threats to the conservation of the region lead us here to propose a 7 week field expedition to the mountains. We aim to complete the first systematic mammal survey of the high slopes, only the third bird survey and by employing for the first time state-of-the-art ecological sampling methods, including using Oxford Nanopore Technologies portable DNA sequencer, to maximise our chance of establishing the status of Sir David's Long-beaked Echidna. In so doing we aim to have a significant conservation impact while also adding baseline data to answer outstanding biogeographical questions of the region. This does however exist within the context of continued unrest in Papua between the Free Papua Movement and the Indonesian government. We therefore also propose a contingency plan to sample, to our knowledge for the first time, the closest mountain range to the Cyclops in Papua New Guinea, the Oenake Range at a mere 20 km and therefore also a putative location for the continued existence for the echidna.

Aims

Our principal aim, given compelling evidence for its continued survival exists, is to conduct the first survey employing modern ecological methods for the 'lost' species Sir David's Long-beaked Echidna, *Zaglossus attenboroughi*, on the higher slopes of the Cyclops Mountains of Papua. The methods to be used will allow concurrent mammal surveying, and, complementing this, we intend to carry out ornithological surveys such that in sum we undertake a rapid biological assessment in the form of those conducted under the Rapid Assessment Programme (RAP) of Conservation International (CI), though at a smaller scale.

In so doing, the expedition would be the first to undertake any mammal survey in this region and only the third ornithological survey. By consequence it is our purpose to address several points of interest in the academic community. Concerning *Z. attenboroughi*, the almost unknown nature of its morphology, population or ecology means any information is crucial not only in furthering conservation information of this critically endangered species, but also in enhancing our understanding of the phylogeny and biogeography of echidnas. Indeed, local testimonies suggest that in fact two species of echidna may reside in the region and by employing methods in the form of camera trapping and eDNA sampling we hope to provide the most thorough attempt to date to address these interests. These methods will be conducted as part of a general mammal survey and as such also fulfil the aim to create an inventory of the mammal fauna of the mountains, something not yet achieved. This will help to confirm or not reports of other outstanding mammal fauna such as the presence of tree-kangaroos (*Dendrolagus*) of which only one species is known from the region despite anecdotal reports of at least two species.

Concerning avifauna, the two previous serious surveys, one extensive by Ernst Mayr in 1928, one cursory by Jared Diamond and David Bishop in 1990, both report a relative paucity of bird life in the Cyclops. This makes it an anomaly of the outlying mountain ranges of New Guinea. There are many species located in the surrounding Bewani and Foja ranges unreported from the Cyclops and so in making a further assessment we hope to establish whether this pattern is a consequence of undersampling or whether it may instead reflect a true biogeographic, or of more concern, anthropogenic phenomenon.

This latter effect is possible given the close proximity of Papua's major city Jayapura which has been in existence as an urban centre since soon after its colonial founding as Hollandia by the Dutch. Human encroachment and the negative consequences thereof now severely threaten the Cyclops Mountains and so further research to establish its baseline biodiversity and develop conservation cases is critical. This is only possible by conducting diverse biological surveys, hence our interest in complementing mammal surveys with ornithological in addition. Sustained conservation is only possible with the engagement of local communities and a critical purpose of our research is to partner with local universities to collaborate with researchers and thereby provide training in the surveying skills we employ and distribution of the results we find.

In total, by undertaking the expedition, the evidence that we accumulate could be critical in generating conservation interest in the region which is at current, minimal, and disincentivised by Indonesian foreign policy. This has led for example for the disengagement of the Zoological Society of London from the region. Thus while their EDGE programme funds a local scholar in Papua New Guinea to research the endangered Eastern Long-beaked Echidna, no such equivalent exists in Papua, something for which we hope this expedition can catalyse change.

Justification

In terms of species-based conservation value, *Z. attenboroughi* ranks as of extreme importance. It is no wonder that it is the 'poster animal' for the Zoological Society of London's EDGE programme, emblazoned as it is above these letters in the project's logo. Standing for **E**volutionarily **D**istinct **G**lobally **E**ndangered, this represents a metric by which conservation target species can be defined (Isaac et al., 2007). *Z. attenboroughi* is the joint top priority mammal species alongside its close relative the Western Long-beaked Echidna (*Z. bruijnii*) for this score, a consequence of both being critically endangered (IUCN, 2016) and representing the end nodes of an ancient mammalian lineage, the monotremes. These are the egg-laying mammals, "living fossils" as they were once described (Long et al., 2002), which once existed as a diverse radiation but which now count as their members a mere five species such that all can truly be said to be evolutionarily distinct (see Figure 1).

Furthermore, *Z. attenboroughi* is one of Global Wildlife Conservation's 25 'most wanted lost species', defined as animals that have been unobserved for at least 10 years.

Z. attenboroughi has clear conservation value therefore which makes its actual conservation position, that of very low attention, all the more surprising. Even more so then is this low attention despite compelling evidence that it still exists. In 2007, the then head of the EDGE programme, and now Chief Scientist at National Geographic, Jonathan Baillie lead an expedition in search of the echidna. Using community interviews he found that local people could describe key characteristics of the echidna and recognised photos of them (Baillie et al., 2009). Five people across two communities convincingly described physical encounters with echidnas, all in a hunting context (Baillie et al., 2009), the most recent of which at that time was 2007. Furthermore, trekking in the mountains revealed trace signs of echidna in the form of nose pokes at an altitudinal range from 0 to 1700m above sea level (asl) (Baillie et al., 2009). From this Baillie, perhaps prematurely, concluded the continued existence of *Z. attenboroughi,* and more recent evidence has done little to dissuade this.

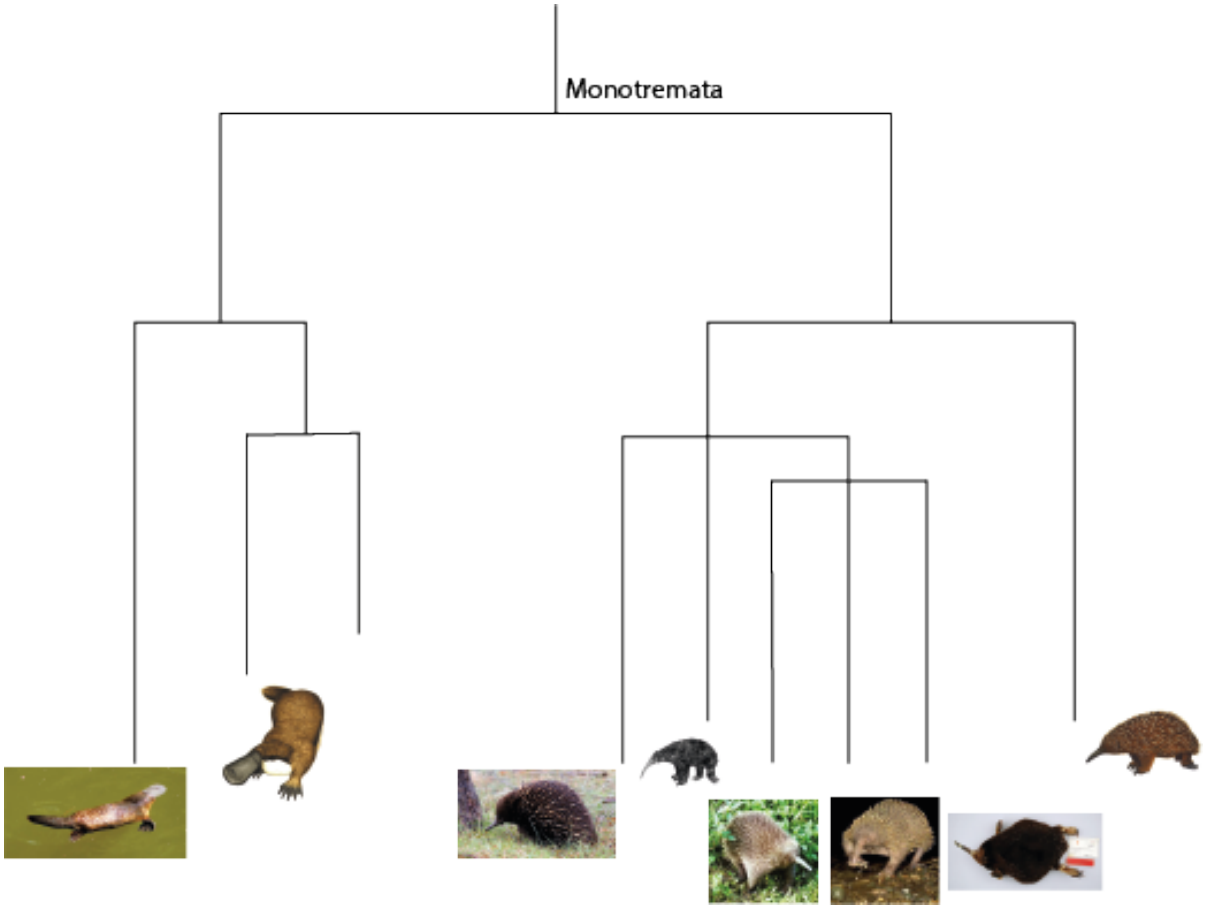

Figure 1: A schematic of monotremes phylogeny from extant and some known extinct species. One clade contains the duck-billed platypus and its extinct relatives, the other the living echidnas and their relatives. From left to right we therefore have: Duck-billed Platypus (*Ornythorhinchus anatinus*), *Obdurodon dicksoni* (extinct)*, Monotrematum* (extinct - missing image), Short-beaked Echidna (*Tachyglossus aculeatus*), *Zaglossus hacketti* (extinct – unresolved position), Western Long-beaked Echidna (*Zaglossus bruijnii*), Eastern Long-beaked Echidna (*Zaglossus bartoni*), Sir David's Long-beaked Echidna (*Zaglossus attenboroughi*) and *Megalibwillia* (extinct).

Paul Barnes (PhD student UCL 2015 -) has been conducting research in the region and in speaking to him, he has revealed to us further support for Baillie's claims. His community surveys have revealed more recent sightings of echidna and in addition he has been shown physical echidna spines.

We cannot of course dismiss alternative explanations for this evidence in the form of fabricated stories, knowledge of echidnas from other sources, misidenfitication of trace signs, or outdated physical material. However, the evidence certainly makes absolute confirmation more pressing and realistic.

This realism exists within the context of very recent other 'lost' species discoveries. Nine days prior to this submission deadline it was confirmed through a paper in *Nature Ecology and Evolution* that another of the 'lost' species on GWC's Top 25 was rediscovered, by camera trap evidence, the Silver-backed Chevrotain in Vietnam (Nguyen et al., 2019). This is in addition to another four of the Top 25 already rediscovered, alongside nine from the total 1,200 species list in 2017.

And this pressingness comes from the imminent threats to the home of the echidna in the Cyclops Mountains, another oddity in the low conservation attention of the animal. One reason the Cylops may represent a refuge for endangered flora and fauna is because its higher slopes are traditionally venerated by local communities. However, increased urbanisation from Jayapura, and immigration from other parts of Papua, are threatening this established form of defence.

The immigration problem poses a particular threat, for peoples arriving from other regions, notably mountainous regions such as Wamena in the Central Cordillera, do not have the same tradition relating to the mountains (Rob de Vos, personal communication). They also practice different forms of agriculture to the indigenous of the region and as such swidden agriculture, settlement encroachment and illegal logging all represent threats. Of particular concern is that these threats are moving up in altitude with the less steep southern slopes now particularly exploited (Baillie et al., 2009), thereby threatening the previously undisturbed higher echelons of the mountains.

Excluding swidden agriculture, similar threats exists, as well as road construction, because of population expansion from the city of Jayapura and required urbanisation (Polhemus and Richards, 2002). Of most concern is the recent road construction between the port of Depapre at the Western end of the mountains and Jayapura at the eastern end. The road itself is not necessarily an issue, more so is the context in which it is built. The port project in Depapre appears to represent a means by which to export large quantities of goods to China and its timing alongside the granting of Nickel-Cobalt mining concessions around the Cyclops lowlands is probably not coincidental (Barnes, pers. comm.). The development of this infrastructure will inevitably lead to further population increase with the same problems as discussed in relation to migration population increase. This will also likely impact upon the people themselves for the mountain represents the key freshwater source in the

region, and the degradation of the Cyclops will likely lead to a reduction in its quality with widespread health implications (Polhemus and Richards, 2002). Finally, the release of Javan Monkeys into the mountains may represent an invasive species problem in the future.

Background

Z. attenboroughi is known from a single specimen, collected "Oost-top, Berg-Rara, op 1600m" as Peter Van Royen its discoverer noted on 4th July 1961 in the Cyclops Mountains. It is one of four species which are split into two genera: *Tachyglossus* and *Zaglossus*. The former is the short-beaked echidna, widespread across Australia, stable in status across its range, and with populations in South Eastern Papua New Guinea. The latter contains the three species of long-beaked echidna, of most interest to us, Sir David's (*Z. attenboroughi*), but also the eastern (*Z. bartoni*), and the western (*Z. bruijnii*). Of these latter two specific status is determined by the number of claws on the forefeet, 3 on the former, 5 on the latter. The geographical barrier for these species are the Paniai Lakes of the Papuan Central Cordillera. Both *Z. bruijnii* and *Z. attenboroughi* are critically endangered on the IUCN red list. Indeed on the general rarity of the long-beaked echidnas, the determiner of their systematics, Tim Flannery, notes that during 15 years of fieldwork he only saw one once (Flannery and Groves, 1998).

The Cyclops Mountains are a small range that lie between Tanah Merah Bay and Jayapura (2°35'40.6"S 140°40'04.8"E), the capital city of Papua, the Indonesian portion of the island of New Guinea. Its peak is Gunung Rafeni at 1880m (Polhemus, 2002) and the climate is typical humid tropical with a high annual average (26.5 degrees celcius), and low variance in, temperature. The mountains themselves cover 31,400 hectares and 22,500 ha of this represent a strict nature reserve (Polhemus 2002), but one that is threatened by human activity: illegal logging, road construction, settlement building and swidden agriculture. This has seen encroachment into the protected area (Baillie 2009; Polhemus 2002).

This encroachment is a very modern phenomenon as traditionally very few people have entered the high slopes of the Cyclops Mountains. They are famously difficult to ascend: Jared Diamond, the noted polymath and avid ornithologist noted on the "daily risk of falling off the steep, slippery trails" (Diamond, 2004), while the great evolutionary biologist Ernst Mayr commented on their "terrible steepness" (Mayr, 1930). On the northern side the slopes are notably difficult and few people ascend beyond 400m (Baillie et al., 2009)

As a consequence the site has been poorly surveyed, though some expeditions have occurred. The earliest of note was Ernst Mayr's in 1928. Mayr was collecting for Lord Walter Rothschild, the British eccentric, for skins to be displayed at his zoological museum in Tring (now the Natural History Museum at Tring), alongside for the American Museum of Natural History, and under the supervision of the famous ornithologist Erwin Stresseman. Mayr approached the mountains from the less steep southern side at lake Sentani, as most people do and in total spent approximately 4 weeks on the expedition (Mayr, 1930). Much of this was spent attempting to make camp to reach the higher elevation and this was achieved on the 3rd September 1928. He returned to Ifar, Sentani on the 14th implying about a week's worth of excursions to the higher slopes (Mayr, 1930).

Since Mayr, three notable expeditions have attempted the higher slopes, the first in 1936 was by the intrepid explorer and entomologist, Evelyn Cheesman. She was known to the New Guineans as the woman who walks, an epiphet derived from her rejection of the sedan chair, so normally seen as the mode of transport for western women. She made entomological collections above 1050m on the mountains. From the third Archbold expedition in 1938, some members made forays into the

mountains prior to the commencement of work further inland. And then in 1990 Jared Diamond and David Bishop climbed to the peak over two days to make a bird survey the results of which are on ebird.

Alongside this an RAP was conducted on the coastal lower slopes in 2002 in the region of Yongsu which revealed important insect, reptile, amphibian and fish fauna including the discovery of 3 new species of frog to science, one new fish and a large range extension for a nymphalid butterfly (Richards and Suryadi, 2002). Corroborating Mayr and Diamond's reports, the bird community was somewhat impoverished, but local naturalist reports suggest the region is highly undersmapled for birds. Again, no mammal surveying was undertaken.

In total, previous expeditions and local testimonies suggest a high biological value to the Cyclops Mountains while revealing the chronic undersampling of the region.

Concern

A possible further explanation for the lack of sampling work conducted in the Cyclops Mountains Region is the tension that exists between the Indonesian government and the Papua Merdeka (OPM) movement, a separatist movement that has existed since 1965, 4 years after the hand-over of colonial control from the Dutch to the Indonesians. During this period Papua has most often been open to the outside world, but through a filter imposed by the Indonesian government. In particular this has made foreign research activity difficult.

While at the moment the Foreign and Commonwealth Office (FCO) have granted a green light to foreign travel in Papua, an Indonesian expeditions logistics company, Lahuka, alongside various other academics I have contacted, have informed that obtaining research permits is particularly difficult. I think it prudent therefore to develop a contingency plan following the same motivation. This is outlined in the logistics section.

Methodology

Echidna-specific surveying

The most advanced of our surveying methods, environmental-DNA (eDNA) sampling is reserved for trying to detect the presence of echidnas due to the clear sampling strategy that exists. During the day, echidnas will sleep in their burrows or hollow logs and these therefore represent clear targets for taking environmental samples in the form of soil or detritus. These samples are then processed in case cellular material from echidnas is present as may exist in mucus, hair, skin, or faecal matter.

The method of eDNA analysis is contingent upon the facilities that our collaborating institute possesses. In the absence of sequencing facilities, because of the logistical difficulties of transporting field samples back to Oxford – the material transfer agreement permit acquisition from Indonesia is notoriously hard – the intention would instead be to use the state-of-the-art portable sequencing technology for near in-situ analysis. The principal piece of equipment for this would be the MinION DNA sequencer (Oxford Nanopore Technologies) at 10 by 3.2 by 2 cm and <100 g. The workflow exists as follows:

1. DNA extraction – This requires components for cell lysis, protein precipitation and DNA precipitation. These are commonly sodium dodecyl sulphate and proteinase K, guanidine isothiocyanate and isopropanol respectively, though ready-made preparation kits such as the Puregene DNA purification kit (Gentra Systems) also exist.
2. Target sequence amplification – This requires using the DNA amplification technique polymerase chain reaction (PCR). Again, this needs to be miniaturised for transport so a miniPCR thermocycler (miniPCR) would be used, powered by an external battery. The output of this is amplified DNA sequences of target regions specified by the choice of DNA primers made.
3. DNA library preparation – The output of amplification is a series of target sequences known as amplicons. These need to be prepared for sequencing and the process is known as library preparation in which short adapter sequences are annealed to the 3' and 5' ends of the amplicons. One of these adapter sequences will act as a sequencing primer for the sequencing step while the other will act as a surface actor during sequencing.
4. DNA sequencing – The MinION uses nanopore-based technology to deliver sequencing. In this technology protein nanopores, effectively tiny protein enclosed holes, are embedded into a synthetic matrix that is all bathed in an electrophysiological solution. As DNA passes through the nanopores it disrupts current that is also being applied. The disruption signal is base specific thereby enabling sequence analysis. This raw signal data is generated by the MinKNOW software and subsequent processing is then required.
5. For species identification sample sequences must be compared to known sequences. This can be achieved by reference sequences on the open access database GenBank which at the current time of writing has 7 sequences stored for *Z. bruijnii* and 502 for *T.aculeatus*

The capacity for in-situ use of this technology has been demonstrated in multiple contexts from monitoring of the EBOLA outbreak in West Africa between 2014 and 2015 to sequencing of microbial communities in the Antarctic (Pomerantz et al., 2018). Of greatest relevance to us was its successful employment during a rapid assessment expedition to the Choco Rainforest of Ecuador where it was demonstrated to generate results in under 24 hours and facilitate correct species identification with sequences generated in excess off 99% accuracy (Pomerantz et al., 2018).

All of these field sites had cold storage facilities, necessary for the maintenance of sequencing reagents and keeping MinION flow cells which must be stored between 2 and -8 degrees Celsius. Such cold storage will not be possible at our field site and so samples must be kept and instead analysed using the above protocol at our local collaborating research institute.

Mammal surveying

Mammal surveying will be conducted by camera trap methods. These provide an automated and standardised procedure, reducing sampling bias, and also overcoming the common difficulties of mammal recording, that of shy, unvocal, low density and nocturnal species (Larsen et al, 2016).

Data on species accumulation curves indicate that a recording period of between 3 to 4 weeks is necessary for sampling, something often beyond most rapid assessments, but feasible within this expedition.

Species accumulation curves also suggest between 20 and 30 cameras at a field site with the recommended density being one camera per 2 km^2 (Larsen et al., 2016). Even if we obtain some cameras on sponsorship or borrow cameras it is unlikely financially feasible for us to obtain 30 cameras and so an aim would be between 10 and 20 cameras with a coverage between 20 and 40 km^2 over a broad elevational gradient. Here a physiological limit is imposed on what distances we can travel and so this will also be a constraint.

Ideally the cameras would be randomly placed on a proposed grid but access difficulties will of course constrain this. Cameras need to be place where there is some visual clearance and will therefore be restricted to man-made trails (of which those made by us will be the principal) or animal-made trails, these often existing along ridgelines according to Mayr (Mayr, 1930). It is only via these trails that access to a given grid point can also be obtained. This will bias site selection such that it is ultimately pseudo-random.

The cameras themselves should be placed at a height of between 30 and 50 cm and the GPS position and elevation of each site must be recorded. These positions, alongside the raw video data recorded then represent the output of the surveying method.

It should be noted that the small size of the proposed team will be advantageous in this instance as larger teams tend to reduce mammal presence.

Bird surveying

Bird surveying will be conducted with both audiovisual and sound recording methods. The primary audiovisual method will be point counts.

These should be conducted over 10 minute periods, as justified by species accumulation curves, and in a spatial grid with sites separated by 250m. This distancing encourages spatial independence of sites with 250m an estimate of average call transmission. The count works by recording all birds seen and heard within a 50m radius of the focus over the recording period with age and sex ideally recorded (Herzog et al., 2016). Again, GPS and elevational position of sites must be recorded.

Effective point counts require high expertise in identification which team members do not currently have for the New Guinea avifauna. The designated ornithologist, James Kempton, must therefore prepare in advance auditory and visual identification skills using digital and text references. This can be achieved by compiling a suspected species inventory for the region and then for audio practice using the public digital databases of Xeno-Canto and the Macaulay Library of Ornithology of Cornell. For visual practice *Birds of New Guinea* of Beehler and Pratt, and *Birds of New Guinea* by Gregory

provide comprehensive field sketches and identification notes. This said, a reconnaissance to the region would be useful.

Less demanding of expertise is sound recording because identification can always be achieved post hoc with expert consultation if required. A standard protocol for sound recording is the dawn chorus survey method (Herzog et al., 2016). Here, using a shotgun microphone like the ME 66 (Sennheiser) which has great directional sensitivity, recordings are made in 15 minute periods in a systematic way. Starting at dawn the microphone is first pointed in the direction of highest vocal activity and then rotated 90 degrees every minute such that two full revolutions are completed after 8 minutes. Ad hoc recordings are then made for the remaining seven minutes and ideally 3 such recordings are made per day.

As with point counts sites should be separated by 250 m and their GPS coordinates and elevation established.

Logistics

Bureaucratic access

The logistics of gaining ratified access to the research site can be decomposed into five main parts

1. At home application

For conducting research in Indonesia a Limited Stay 315 Visa is required which is applied for online. This requires the following documents to be uploaded to the application portal (found here https://frp.ristekdikti.go.id/index.php) on the Indonesian Ministry for Research and Technology (RISTEK) website:

1. Formal letter of research permit request addressed to RISTEK and copying in the Indonesian Embassy in London
2. University of Oxford recommendation letters, one from a university official, one from a senior scientist
3. Letter of acceptance from Indonesian host research institute
4. Supporting letter from Indonesian host institute
5. Letter of agreement between University of Oxford and Indonesian host institution
6. Research proposal abstract
7. Research proposal
8. List of research equipment and its value
9. Passport scan
10. CV
11. Indonesian host institution counterpart CV
12. Red background photo
13. Bank account copy displaying > $1500
14. Health certificate

Elements 3., 4., and 5., and the development of 6., 7., and 8., all require collaboration with an Indonesian partner. So far I have contacted the Universitas Cenderawasih (UNCEN) in Jayapura, Universitas Papua (UNIPA) in Manokwari and the Research Centre for Biology (LIPI) in Cibinong, Java to discuss my research ideas and develop meaningful collaboration.

2. Jakarta

Once in Jakarta the physical copies of permission documents must be obtained and paid for. This requires bringing hard copies of all of the soft copies so far submitted. These permission documents to be obtained are as follows:

- The physical research permit (SIP) and 5 copies of cover letters for subsequent organisations. These are collected at the RISTEK headquarters
- The Surat Jalan (SJ), a permit allowing travel within Indonesia and acquired at any police station
- The research notification letter (SPP) of which obtainment requires all permits acquired so far and which is acquired from the Department of Political and General Affairs

3. Jayapura

The closest major town to the field site is the Papuan capital of Jayapura where the next bureaucratic stages should take place and the following permits acquired:

- The Limited Stay permit (KITAS), required at most 30 days after arrival

- Permit from the Political and National Unity Agency whose obtainment and nature are as of yet not entirely clear to me but seems to require disclosure of all towns and villages you intend to visit
- SIMAKSI permit, a permit allowing access into protected areas, as the Cyclops Mountains are, and which is acquired from the local Natural Resources Conservation Institute (BKDSA)

4. Traditional land access

The above procedure is a necessary but not sufficient condition for access to the field site. They are formal requirements imposed by the Indonesian Government, but local land ownership beliefs must also be respected. Given the local tribes of this country have existed in the region far longer than the Indonesian sovereignty, their traditional rights must be respected. This is impossible to each ex-situ and must be completed on arrival at the field site region. To facilitate such a process I have been in discussion with Paul Barnes (PhD student University College London 2015-) who has worked extensively in the area. He has provided local fixers, most notably 'Bang' Dani, a local who provided Paul with driving and liasing services. In order to arrange community authorisation for example this can require extensive travel in order to meet with the Kepala Campung (village chief) of land-owning communities in the region. Their villages are widespread and so Dani provided Paul the driving and logistics necessary up to the village of Dormena where the road then stops. Subsequent access is then via boat. The land-owning communities broadly map to the language groups of the region from which we can see by the map there are four principal contacts that must be made.

5. Exit-only permit

In order to be able to leave the country an exit-only permit is required to nullify previous obtained permits. This is obtained from the immigration office in Jayapura, where the KITAS is acquired, and upon receipt, one has 7 days to leave Indonesia, thereby imposing the final constraint on time logistics.

Field site access

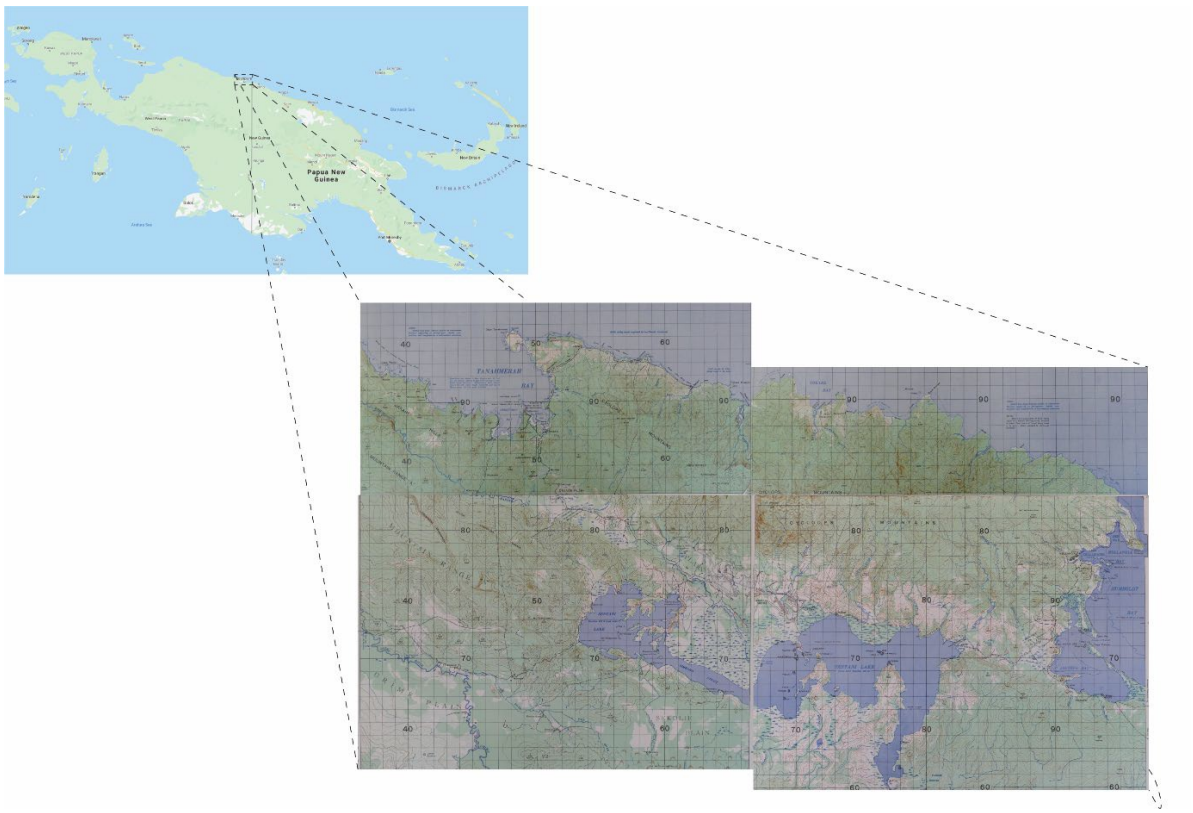

Figure 2: Detailed maps of Papua are extremely hard to source. The stitched maps on the right are 1943 US Army Corps 1:63600 scale maps of the Cyclops Mountains region. Previous expeditions have tended to ascend form the Lake Sentani, the inland large water body that can be seen. We instead propose to ascend from either the western or eastern tips of the range and follow the ridgeline along which there exist animal trails making passage easier (Paul Barnes, pers. Comm.).

Contingency plan

In the case of denied research permits for Papua making legal research impossible we have developed a contingency that has broadly the same aims with the same motivation. As noted by Diamond (1985), there is a species composition similarity between adjacent outlier ranges in New Guinea. For this reason he grouped the Bewani, Torricelli and Prince Alexander ranges as one ecoregion, terming them the North Coastal Range (Diamond, 1985). The Bewani, at the western edge of this group lie approximately only 40 km from the Cyclops and could be expected therefore to have a similar fauna. While Flannery (1998) worked extensively in this range he did not use the modern ecological methods proposed here and the existence of an exciting mammal fauna is a distinct possibility. Even more intriguing is the existence of a small range lying a mere 20 km from the Cyclops, right on the Papua New Guinea-Papua birder known as the Oenake Range. While the highest peak of Mount Bouganville only rises to 1200 m, this is still well within the range of the elevational distribution of echidna evidence from the Cyclops. Finally, while the Bewani was surveyed ornithologically by Diamond in 1969, this represents the solo major effort and resampling it has been a high priority of other specialists of the region, such as Bruce Beehler (pers. Comm.) for some time.

An expedition to the Oenake and Bewani ranges, employing the same methodologies proposed thereby provides a feasible alternative for answering many of the same questions to the discussed expedition.

In developing this contingency I already have as a local agent, Vojtech Novotny, Director of the Binatang Research Centre (BRC), the major NGO research institute of Papua New Guinea. For such an expedition the BRC would work as our local collaborator institute and Daniel Okena become a member of our team, his expertise to the project being detailed in the personnel section.

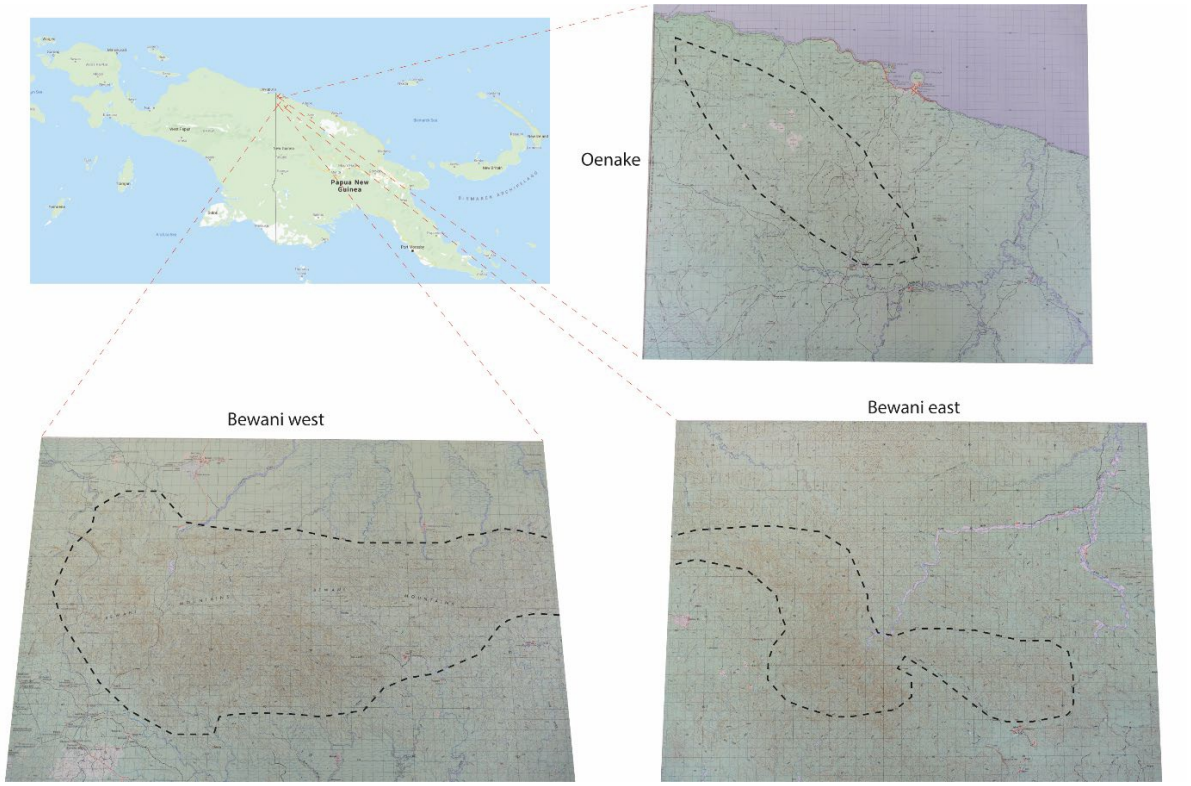

Figure 3: Maps from 1974 Australian Engineer Survey Team of the Oenake and Bewani Ranges. The expedition would start out from Vanimo, the pinchpoint on the coastline of the Oenake map, travelling to Mount Bouganville at the peak of the Oenake and then descending the ridge to move to the more southerly Bewani Range.

Personnel

James Kempton – Expedition Leader, Chief Scientific officer

3rd year DPhil student in the Department of Zoology, University of Oxford researching flight energetics in pelagic seabirds and guidance and control of pursuit behaviour in hawks at the Oxford Flight Group. James has conducted fieldwork in the Cairngorms of Scotland and at the Tour du Valat Research Station in the Camargue, France. As part of his DPhil he has skills in data collection, processing, visualisation and analysis, particular with regards video and 3D position data, achieved via a competence in the MATLAB programming language. He has independently organised two holiday-style expeditions to Madagascar and Costa Rica, the former of which he acquired competitive funding for and which included a 3-day trek in the Isalo gorges. Physically he has competed cycling hill time-trial competition and is a member of the university cricket and real tennis squads. During his time as a DPhil student he successfully competed in University Challenge and has performed stand-up comedy at various venues in Oxford. His greatest passion is birdwatching and he has now compiled a world-list in excess of 1,000 birds.

Laura Perry – Treasurer, Scientific Officer, Medical Officer

3rd year DPhil student in the Department of Zoology, University of Oxford researching human-wildlife conflict in Sub-saharan Africa at WildCRU (Wildlife Conservation Research Unit). Laura has considerable field experience in South Africa, Botswana, Mozambique, Tanzania, Kenya, Ethiopia and Zambia. To be competent in achieving this fieldwork she learnt kiSwahili and has become a competent bush driver and car mechanic. Many grant applications and risk assessments were written in the funding of her work and as a consequence of its impact she is now a National Geographic Explorer. In addition she is a level 2 first aider and competent diver.

Charlie Northcott – Chief Medical Officer, Chief Communications Officer

Investigative journalist and documentary producer at the BBC. Charlie has been working with the BBC World Service for the past four years after graduating in History from the University of Oxford in 2014. In particular he has worked as producer for a branch of the world service known as Africa Eye, an investigative unit, which launched last year, aimed at creating high impact journalism which holds power to account in challenging parts of the continent. As such he works primarily out of West Africa and Nigeria in particular. Through his journalism he was part of a team that won a Peabody Award for human rights reporting in Cameroon earlier this year, and an Emmy nomination for an undercover investigation into the pharmaceutical industry in Nigeria. He has frequently operated in conflict zones and looked after teams in tricky terrain. He has covered war in the Sahel, Ebola, unrest in Sudan, and has worked in similarly difficult environments in South America and the Middle East. He has advanced first aid training and has the BBC's top band of hostile environment training. As part of the BBC he has much experience of applying for grants and a strong network of fixers and contacts throughout the world. He also has some scientific journalism experience having written during a freelance period for Smithsonian Magazine, covering eastern wolves genetics and walrus haul-outs in

Canada. He also shoots video and photos professionally, and has some macro photography and camera trap skills.

Papuan research institute collaborator – As yet undetermined

As of yet I have had no response from my reaching out to Indonesian universities for research collaboration. However, I have been in contact with Yance de Fretes who now works as an environmental advisor to a resource company in New Guinea but who has worked in the past on the most ambitious recent Papua expeditions, most notably the 2005 and 2007 CI expeditions to the Foja Mountains in which airlifted scientists reported a 'lost world' like environment with multiple new species to science discovered. In all cases he would act as my **local agent**.

Contingency collaborator – Daniel Okena of the Binatang Research Centre – Scientific officer

Daniel is an EDGE fellow of the ZSL working on *Z. bartoni* in Papua New Guinea. In this capacity he has so far lead in the construction of the Supa Biological Research Station, a dedicated institute for long-beaked echidna conservation, and in the conception of a monitoring programme for *Z. bartoni* in the YUS Conservation Area. Alongside this role he also works for the Tree Kangaroo Conservation Program and therefore has a near unmatched knowledge of the larger mammal fauna of Papua New Guinea.

Schedule

The plan is to conduct the expedition between the 3rd of October 2021 and 20th November 2021. The start date of the expedition is designed to fall after the thesis submission of the DPhil candidates and to minimise the proportion of the study conducted during the rainy season (November to April with heaviest rainfall December to April). The 7 week long duration is a function of the bureaucratic logistical constraints and the methodological justifications for survey duration. Thus we propose the following schedule:

Date (all 2021)	Activity
3rd Oct. – 4th	Flight from UK airport to Soekarno-Hatta Airport, Jakarta
4th – 11th	Stay in Jakarta to complete administrative requirements here
11th	Flight from Jakarta to Sentani International Airport, Jayapura
12th – 16th	All team members stay in Jayapura, one to complete Indonesian administrative requirements, one to obtain local community consent and one to liaise with the local research collaboration
17th	Trek from Lake Sentani to mid elevation stop
18th	Trek from mid-elevation stop to higher elevation base camp and construction of base camp
19th – 21st	Trail construction, sample site determination and establishment of camera trap network
22nd-9th Nov.	Daily bird and mammal surveying activities and data processing and analysis
10th -11th	Descent to Lake Sentani
12th	Obtainment of exit-only permit triggering 7 day release time
12th – 17th	DNA sequencing and analysis at local collaborator institute
18th	Flight from Jayapura to Jakarta
19th – 20th	Flight from Jakarta to UK airport
20th	James' birthday!

Budget

Item	Cost
Transport	
3 × London-Jakarta return (pp.)	**3 × £516 = £1548**
3 × Jakarta-Jayapura return (pp.)	**3 × £367 = £1101**
Jayapura driver (pd.)	**5 × £50 = £250**
Administrative	
KITAS fee	**£113.20**
SIMAKSI <1 month fee	**£274.70**
Limited stay visa 315	**£128**
Research permit registration fee	**£5.50**
Research permit fee	**£137.90**
Surat Jalan fee	**£38.71**
Equipment	
Oxford Nanopore MinION[1]	**£774.15**
miniPCR thermocycler	**£452.88**
Thermocycler external battery	**£116.12**
Fisherbrand mini-centrifuge	**£178.00**
Sennheiser ME66 Shotgun Microphone	**£136.99**
Bushnell Trophy Cam or equiv. × 10[1]	**£130 × 10 = £1300**
Health and safety	
Wilderness Medical Training Far From Help course	**£360**
First aid equipment	**£500**
Methodological training	
Camera trap training course	**£280**
Other	
22 nights accom. @ £10 estimate pppn.	**22 × 3 × £10 = £660**
Food estimated £7 pppd.	**49 × 3 × £7 = 1029**
OUEC bulletin	**£200**
Porter costs	**£500**
Subtotal	**£10084.15**
Contingency @ 10%	**£1008.42**
Total	£11092.57

[1] Cost reduction will be attempted here by sponsorship appeal, renting equipment, or borrowing equipment

Possible sources of finance

Source	Value
Scientific Exploration Society: Sir Charles Blois Award for Science and Adventure	£5000
Oxford University Expeditions Council Award	£1500
Royal Geographical Society: Geographical Fieldwork Grant	Up to £3000
Royal Geographical Society: Neville Shulman Challenge Award	£5000
National Geographic: Biodiversity and Exploration Grant	Up to £38737
National Geographic: Recovery of Species on the Brink of Extinction Grant	Up to £23242
National Geographic: Early Career Grant	Between £3373 and £7747
The Linnaean Society: Systematics Research Grant	£1500
Gilchrist Trust: Expeditions Grant	Between £1000 and £2000
Mohamed bin Zayed Species Conservation Fund	Up to £19368
Brasenose College: Michael Woods Travel Grant	Up to £1000

Risk Assessment

Hazard	Severity	Risk	Precaution
Universal			
Transport	High	Low	All driving duties are to be passed to an Indonesian national holding the necessary in country permits. In Jayapura, a potential driver has already been identified who safely ferried Paul Barnes during his multiple stays there. Otherwise public transport or the use of taxis will be employed.
Immunisable diseases	High	Low	Ensure all courses for UK-advised immunisable diseases are complete (MMR, DPT, …). Assess the likelihood of contraction of local immunisable disease given precautions taken elsewhere (for Indonesia – Rabies, Typhoid, Cholera, Hepatitis B, Japanese Encephalitis). By appropriate treatment of food and water Typhoid and Cholera risk can be reduced. By avoiding handling mammals, which our surveying methods ensure, Rabies risk can be reduced. Hepatitis

			B risk can be reduced by avoiding drug usage, ensuring all medical equipment is properly sterilised and by refraining from unprotected sex. The risk level of Japanese Encephalitis is harder to assess given unknowns in the environment and as a precaution team members will obtain this vaccination.
Non-immunisable diseases	High	High	Papua is a high risk region for malaria. Initial precautions will be in place to minimise mosquito bite risk and include the application of anti-mosquito products, the wearing of long-sleeved garments and sleeping in mosquito net protected hammocks. In addition, all team members will take anti-malarials either atovaquone, doxycycline or mefloquine depending on medical advice and personal histories of their usage. Schistosomiasis risk will be minimised by water treatment. The risk of dengue fever, also being transmitted by mosquitoes, will be minimised by the same initial precautions as for malaria as will that of Zika. The risk of gastroinstetinal problems will be minimised by the proper treatment of water using chlorine dioxide tablets. It is not expected that man-made pollutants will effect water sources in the higher slopes of the Cyclops. To avoid initial contamination of water, all water collection will be done upstream of washing activities. To minimise the risk of gastrointestinal problems resulting from food, all hot food must be adequately heated through and all cold food must be of a non-perishable nature. All food preparation will be done with the necessary hygiene precautions in place.
Climate	High	Moderate	The research location is typically tropical with high temperatures and high humidity. Dehydration therefore becomes a significant risk as does heat stroke and sunburn. To minimise risk of the former each team member must have adequate water supply. This can be facilitated by higher capacity water storage containers such as a CamelBak. Prior to any trekking activity the estimated time to the next water source must be considered and the appropriate quantity of water brought for the worst case scenario. To minimise the latter high factor sunscreen must be applied while long sleeved garments protecting against the sun should also be warn. Finding areas of shade is paramount and strenuous activity should be confined to the cooler parts of the day.
Generic			

Venomous bites	High	Low	Snakes, scorpions, centipedes, red-back spider, mouse spiders and funnel-web spiders represent the main venomous bite threats. Data on the latter 5 groups is less prevalent but the situation with snakes is clear. New Guinea possesses 112 species of snake, 37 of which are venomous and 6 of which are life threateningly so. These 6 are: Papuan Taipan, Papuan Black Snake, Papuan Brown Snake, New Guinea Small-eyed Snake, Papuan Mulga Snake and the New Guinea Death Adder. None of these species are however believed to exist in the Cyclops Mountains. Regardless any bite from the aforementioned organisms will be treated as an emergency triggering an evacuation response. To minimise the risk of this eventuality the area around base camp where sleeping hammocks and the mess tent will exist will be cleared of low foliage to make detection easier. Trails will be cut to all communal areas and team members will only be permitted to walk these trails, all the time while wearing rubber boots. Prior to putting on clothing or using sleeping hammocks, all items must be checked for envenomating animals.
Non-venomous bites	High	Low	New Guinea possesses no large carnivorous mammals and the danger thereof is nulled. Traumatic bites from small mammals is of course still possible and so a blanket ban on handling animals will be imposed.
Difficult mountainous terrain	High	High	The slopes of the Cyclops Mountains are notoriously steep and heavily forested. This makes trekking difficult especially when the ground is uneven, slippery and possibly unstable. The risk of injury, including severe injury, is therefore of concern and several precautionary strategies will be employed. Firstly, the route of ascent will be carefully planned so as to minimise elevational gradients. Approaching from the eastern or western tips of the range is easiest in this sense. Where possible existing trails will be used. These may exist from animal movements or hunter's tracks and previous expeditions have noted they exist, especially on ridgelines. Guiding us in route choice will always be locals of the regions who know the mountain well. During periods of trekking the utmost concentration of team members will be required as will the free use of both hands.
Rivers	High	Low	The ascent route has been designed so as to avoid river traversing. Base camp will be set up at a suitable distance from rivers in case of flash floods.
Physical exertion	High	Moderate	In the tropical climate of the region the effect of physical effort is magnified. There is a risk then of exhaustion and heat shock. To reduce this risk maximum carrying allowance will be set in advance at 10 kg. Realistic achievable aims will similarly be set

			with travel distances not expected to exceed 2 km per day. Frequent rest and hydration stops will be made and pace will be set according to the weakest member of the team with no-one pushed beyond their limit. In advance of the expedition all members of the team must have done preparation training, especially in endurance and it will be the role of the team leader to ensure that this is followed. Medical checks by qualified practitioners must be undertaken on all team members prior to the expedition such that an informed assessment of their physical condition is made.
Specific			
Cassowary	High	Low	Likely the most dangerous animal of the Cyclops Mountains is the Northern Cassowary. Females can attain 58 kg and 1.8 m in height. Cassowary attacks are often associated with human feeding and so team members are not allowed to leave food out that may attract cassowaries to the base camp. Under no circumstances are seen cassowaries to be approached.
Free Papua Movement	High	Uncertain	Tensions between the Free Papua Movement and the Indonesian government have existed for greater than 50 years with many research expeditions and tourist visits taking place during this time. Recent conflict has been extreme however and an epicentre has been Jayapura. While the FCO maintains a green light on travel to Papua it does warn to avoid large gatherings and protests and to follow local media and the advice of local authorities in avoiding conflict. This advice will be heeded and travel and accommodation itineraries made so as to avoid troublesome areas.
Machete usage	Medium	Low	Machetes will be required to clear trails in the thick rainforest. Where at all possible machete usage will be designated to trained local guides. If impossible and a team member is required, they will take the lead of the file and ensuring there is a large clearance between them and all others operate the machete at arm's length in from them ensuring a firm hold of the blade.

Crisis management plan

In the event of an emergency the following crisis management plan will come into effect with the necessary prerequisites noted.

Prior to departure the nearest definitive care facility must have been ascertained. For this expedition this is most likely to be Darwin, Australia given the poor facilities at Port Moresby hospital. However, we are currently undertaking research to see if there are any private hospitals associated with foreign industry in the region. In either case this hospital will be notified in advance of the expedition and the existence of the crisis management plan.

A clear signal that the crisis management plan has come into effect will be pre-arranged. This will be a whistle of which each team member will carry one. Upon the sounding of this whistle prearranged roles in the plan must be adopted.

The Chief Medical Officer will take the principal role here in administering temporary care. All critical notes will be written on the patient themselves given the issue of future note transfer. However, the Medical Officer will also be acting as scribe taking notes of the key events and their timing and taking photos. The Chief Medical Officer will decide on what level of medical action is required and determine whether evacuation is necessary.

If evacuation is necessary this will likely only be feasible by helicopter. In advance of the expedition emergency helicopter services will be contacted to establish the feasibility of airlift form the region. The position of our base camp and sample trails relative to any landing site must be known to all team members and evacuation routes for different potential accident localities must have been pre-planned.

It is the Expedition Leader's responsibility to ensure that all necessary communications are with the moving team and that there are still sufficient at the base camp so that remaining team members have access. The complementary decision making regarding medical equipment will be done by the Chief Medical officer.

The Expedition Leader will need to call the insurance company to inform them of the actions taking place.

The Chief Medical Officer will prior to loading of the patient into the helicopter ensure all desired checks and treatments have been applied and will then accompany them to the hospital. He will remain with the patient at the hospital liaising with the in house staff and ensuring all medical documents are photoed.

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