CONSERVING CAVE ECOSYSTEMS AND PUBLIC HEALTH

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Cave ecosystems are similar to those of oceanic islands, isolated by land instead of water. As with oceanic islands, they are sensitive to disturbance and effects of invasion by other species. As man explored, discovering islands, they exploited the local wildlife for food. But in many cases it was what was left behind, that caused more destruction ask the Dodo and its friends?

On the island of Guam (western Pacific), at the end of World War II (1945), scientist started to see a decline in bird numbers on the island, by the mid-1980's eleven bird species were extinct. Many theories surrounded the extinction of these birds, ranging from testing of chemical weapons to typhoons. Eventually the culprit was identified; a snake (Boiga irregularis). Probably introduced onto the island as a pet or transported as part of cargo unintentionally, during WWII. Having no natural predators on the island, these snakes increased steadily in number, having an abundant supply of bird chicks to eat. While the birds on the island having never encountered a snake before, did not have any defensive strategies in place to prevent their chicks from being eaten. As no new birds were surviving to adult hood (or very few), eventually the older birds became too old to reproduce and died extinction of species.

There are many examples where introduced species have or are causing the extinction of native species on islands. It is easy to see extinction occur on islands, but it is also occurring on the main land think of the spread of some plants or bird species that are taking over or displacing natural species where you live?

But, the biological world is not limited to species that we can only see. There is a large microbial world that is in desperate need of discovery and understanding. This microbial world can broadly be divided into four main groups protozoa (e.g. Plasmodium [Malaria], Trypanosoma [Sleeping Sickness]), fungus (e.g. Histoplasmosis [Cavers disease]), bacteria (e.g. Liptospora [Leprasy], Riketsia [tick bite fever]) and viruses (e.g. Coronoviruses [Common cold, SARS], Filoviruses [Ebola, Marburg]).

The effects of an introduced microbial pathogen into caves and mines in North America some time before 2007, has been well documented. In Albany, New York, USA, bats were seen to be flying during mid-winter (unusual behaviour), and thousands of dead bats were found in caves at the end of the winter season 2007. Upon investigation of these caves and mines, it was noticed that the surviving bats had white noses. The term White Nose Syndrome (WNS) was born. Further investigation showed that the white seen on the noses of these bats was a fungus. The spread of the fungus as well as the deaths of hundreds of thousands of bats has been tracked across North America over the past nine years (95% death rate in some populations). In 2012, bat biologists and fungus experts identified the fungus as Pseudogymnoascus destructans, a common fungus found in soils of European caves. This fungus was inadvertently introduced to a cave or mine in Albany by a bat researcher, caver or tourist, who transported fungal spores from Europe to the USA. European bats are unaffected by this fungus, possibly due to these bats havening developed an immunity to the fungus tens of thousands to millions of years ago. The fungus burrows into the wing tissue of the bats causing both damage and also irritation waking up the bats during hibernation. The awake bat then leaves the roost (term used is indicate where a bat lives) to search for food. But in the dead of winter there is no food (insects) available, this expends more energy and burns up remaining fat reserves. The lack of fat reserves to last the bat for the remaining time of winter, leads to the bat dying.

WNS fungus (Pseudogymnoascus destructans) likes cold caves/mines of Europe and North America to

survive. Therefore, the risk to bats in South Africa or elsewhere in the warmer regions of Africa is highly unlikely (but higher altitude caves may provide conditions suitable for this fungus). But, what other pathogens (protozoa, fungus, bacteria or virus) may we as humans spread not just globally, but regionally to the bats; other cave ecosystems or to other none cavers whom come into contact with clothing and gear that has been in a cave or mine? North America took notice of WNS as there were reports of thousands of bats dying. The reduction in bat populations also correlated with increases in crop damage, caused by insects. This meant that farmers in the regions where bats were dying needed to purchase additional pesticides. This meant increased costs to the farmer and hence the consumer. Now there is a call to action as there is a measurable economic price that is being paid. What about the impacts that don't have a direct impact on man (public health) or our economics? who cares?

Over the past 10 15 years via the media we have been exposed to recent global human health risks, like HIV, Avian and Swine Flu, SARS, Ebola, Marburg to name a few. For some, vaccines can be manufactured easily, while for many there is no cure (e.g. HIV, Ebola). All cavers know of Histoplasmosis (Cavers Disease), which is caused by someone inhaling the spores of a fungus. Most individuals who are exposed, their bodies can produce antibodies to fight and kill the pathogen. This is also true for many other possible pathogens that a caver is exposed to. But those who are young, old or immunocompromised are at serious risk of not being able to create antibodies, to fight off the pathogen, which may lead to sickness and/or death. There are documented cases in South Africa, where non cavers (family members and domestic help) have contracted Histoplasmosis. These individuals came into contact with the fungal spores that were transported on shoes, clothing (coveralls) and/or gear.

The cave environment is teaming with microbial life (not just Histoplasmosis) because we can't see it, we don't take notice of it. But walking or crawling in these environments, we pick up on our bodies, shoes, clothing and gear this microbial life from the soil, water and air. We then transport this microbial life, back home where it may come into contact with others who may not be able to produce the immune response that you can.

Alternatively, you move from one cave to another releasing a new pathogen into the new cave ecosystem (e.g. something like WNS mentioned above). In many cases there may be no effect or the conditions are not suitable and the pathogen dies. But, there is the one in a million/billion chance where someone moves a pathogen into an environment where it can take hold and cause the extinction of other microbial life yet to be discovered and/or other troglobites.

Only over the past few years have we come to understand the importance of our own gut microbial flora for the health of a person. We know next to nothing about how microbial life in a cave contributes to troglobite diversity and cave health and function. Cave ecosystems may crash or dynamics within the cave may be altered and we just don't know it, as we are currently not monitoring it or understand it - to be quite honest. So what if a bunch of microbial life goes extinct? The same could be said for the Rhino and many threatened species.

There is a classic example if you were flying in an aeroplane - how many rivets or bolts in the wings of the plane are you prepared to remove (loose), before you put on a parachute and jump or wait for the plane to crash? An ecosystem is like the plane, and the species are the various parts (bolts and rivets) of the plane. How many are we prepared to loose, before the system crashes, and we are then affected?

Microbial communities are only now being studied with many of these microbes leading to commercial uses. Who knows what microbes are hidden in some cave, that can deplete radioactive waste or some other amazing advancement to fix the errors that the human race has created or will create in the near future (Trump for president)?

How can we as responsible troglodytes (gatkruiper or caver if you prefer) reduce the risk of transporting possible harmful pathogens between caves and other loved ones? It is simple, we just need to adopt some basic decontamination protocol's before entering and exiting a cave system.

Decontamination: what is this and why?

"Wash your hands, after using the toilet" is a decontamination process that has been drummed into us since learning to use a toilet. Why do you need to wash your hands after using the toilet? It is to remove possible microbial life (pathogens) that you pick up from your own gut, and then transport and deposit them wherever you touch with your hands - door handles, table tops, kitchen utensils…etc. Others touching these same surfaces pick up the microbes, then they eat a 'washed' apple but the microbes are on the hands of the person eating the apple, which then means the microbes are ingested. Most microbes we ingest have no negative effects. In some cases, they are beneficial as they keep our immunsystem on its toes or assist our own bodies (probiotics). BUT, when we come into contact with a strain of microbe that is different from ours. Our bodies react causing diarrhea and other negative side effects.
Remember the saying "Wash your hands before you eat". Aag Ma, I washed them this morning.
Decontamination is basically cleaning/killing of microbial life that you may be carrying on your body, clothing and gear not just your hands.

Why decontamination?

Caves and mines are unique subterranean environments in which various microbes live and thrive. Many of these microbes are benign (have no negative effect), but a few are known to cause serious human health concerns (e.g. Histoplasmosis, Liptospora). Many of the species that live in a particular subterranean environment are adapted to these microbes, but if a foreign microbe enters the system it may have devastating consequences (e.g. White Nose Syndrome in the US).
Decontamination should not just be for human health risk, but also to reduce risks to the discovered and undiscovered biodiversity living in caves (bats and other troglobites). As a responsible caver all equipment and clothing (especially soles of shoes/boots) that has entered a cave should be decontaminated. Natural pathogens may be deposited on equipment and then transferred to infect other individuals/species.

Why not just use soap and water?

Due to the microbial life becoming resistant to many soaps hospitals provide 'industrial' strength hand washing detergents. Similarly, many of the microbes that you may pick up in a cave will most likely be able to withstand the onslaught of normal anti-microbial soaps.

When to decontaminate?

All equipment and clothing, including shoes/boots and gloves used within a cave should be decontaminated on leaving the cave. Before entering, it is assumed that all equipment was decontaminated when exiting the last cave on previous trip, and your equipment has been washed/cleaned as per normal.
For those who have never decontaminated equipment before. Then it is recommended that you do this before you enter you next cave over the weekend.

What to use:

Bleach (Sodium Hypoclorite)
The most effective method to kill most microbial life is to apply a 10% bleach (Sodium Hypoclorite) solution (diluted with water) for general broad applications. In South Africa a popular brand name is Jik. Any bleach will do. Do not use thick bleach as this clogs spray nozzles and also contain other chemicals. See below for further information on how to prepare the solution.
Most pathogens (i.e. bacteria, fungus and viruses) will be killed within one minute of contact with a 10 % bleach solution. Therefore, on exiting of a cave everyone just needs to be sprayed down from top of head to under the soles of the feet, front, back and both sides (under arms) and we are ok.

F10SC Veterinary Disinfectant

BUT, life is just not so straight forward. There is one serious problem, bleach is corrosive, therefore sensitive caving equipment (i.e. ropes, harnesses, caving ladder…etc), the use of bleach is NOT RECOMMENDED. Currently most manufactures recommend to clean equipment with only water as they are concerned about the integrity of the equipment with the use of 'chemicals'. There is a desperate need for the global caving community to engage with equipment manufactures to recommend suitable decontamination cleaning procedures for their equipment that they approve will not compromise the safety integrity of the equipment, while also decontaminating the equipment for conservation and public health.
F10 is a total spectrum disinfectant that, has no adverse side effects on people, animals, or on equipment and surfaces. It is ecologically friendly and biodegradable, and carries a wide range of registrations and approvals from around the world.
Ask your local vet (animal clinic) for a supplier in your area, or purchase small amounts from them, when and if you need to decontaminate sensitive equipment. A 1: 100 F10 solution is recommended.
But the disadvantage is that a minimum contact time of 30 minutes is needed before anyone should leave site to travel home or come into contact with loved ones. Compared to the use of a 10% bleach solution which kills most pathogens with a 1-minute contact time.
So use your discretion for which product to use or combination of the above is recommended.

First things first: Preparation

Before entering a cave:
1. Check that you have made up sufficient 10 % bleach and F10 (if any safety equipment is needed for the particular cave) 1: 100 solution in spray bottles (clearly mark the bottles use duct tape to label around the spray bottle - red to indicate bleach, and green for F10):
    a. Creating a 10% bleach solution for decontamination
        i. 100 ml of bleach is to be diluted in 900 ml of water.
        ii. For general use, a 750 ml to 1 litre spray bottle may be used.
        iii. For cave decontamination it is recommended that a minimum of a 5 liters (500 ml bleach in a 4.5 liters of water) pump action spray bottle is used (group size of less than 5), and 10 liters (1-liter bleach) for 10 persons, rule of thumb allocate a minimum of 1 liters diluted 10% bleach solution to every member of the team entering the underground location (cave).

NOTE: 10% bleach solution should be made up freshly every 24 hrs. If this is not possible then the contact time needs to be extended. Container which stores the 10% bleach solution should be kept out of direct sunlight, to reduce the breakdown of the chlorine in the mixture.

    b. Creating a 1:100 F10 solution for decontamination of safety equipment
        i. 10 ml of F10 is diluted in 1 liter of water container (so 990 ml water).
        ii. Sensitive equipment needs to be thoroughly sprayed therefore depending on the amount of equipment the amount needed may vary. It is estimated that 200-250ml should be allocated per harness and other equipment. For ropes then at least 1 liter per 20 m of rope should be applied. F10 needs a longer contact time of about 30-40 minutes for it to be effective. The F10 solution should not evaporated/dry before this time has elapsed. See below of procedure at home to correctly decontaminate gear.
2. Designate an area where the bleach/F10 bottles are located (notify all participants where this is). This should be in a shady spot near the entrance to the cave. Please remember that the sun changes direction so make certain that these bottles are kept in shade while you are underground. In some cases, under a vehicle may be the only shade available just remember not to lean against the vehicle or open the vehicle until everyone is decontaminated. The first out is to move the bottles way from the vehicles closer to the cave entrance. This will reduce the amount of time bleach is exposed to direct sunlight.
3. The designated decontamination area should not necessarily be at the immediate entrance to the

cave, but preferably on level ground where it is safe and secure.

4. If you have individuals (loved ones) on the surface, waiting for you to exit the cave they should not come within 5 m of you until you have completed the decontamination process below. You do not want to possibly transmit a possible harmful pathogen to your young child or loved one.

Decontamination exiting a cave or mine

Decontamination when exiting a cave/mine has two primary objectives: -

1. Human health related Pathogens stored on clothing (i.e. coveralls, soles of boots) may be transferred back home where children or whomever washes (plays) the clothing may be exposed to the pathogens (histoplasmosis or other pathogens), even though they did not enter the cave. These risks are small, but they are not worth, particularly as small children, the elderly, and those with compromised immune systems are more susceptible to pathogens.
2. Conservation Pathogens inadvertently moved from one site to another may alter unique cave ecosystems. At the microbial level past caving practices may already have altered these systems. However, given the results of White Nose Syndrome in the USA it is not worth risking further man made introductions through negligence.

Procedure

a. Everyone exiting the cave must first be decontaminated at the designated area. Someone who didn't enter the cave may be designated to assist with the decontamination process (they should wear N95 face mask), or those exiting work in a buddy - pair system assisting one another. All other people (especially children) who did not enter the cave should move away from the decontamination area when it is being used, as spores and particulate matter from the cave may become air borne during the procedure.
b. Harnesses or any safety equipment worn by the caver should be removed first. The safety equipment can then be sprayed with the F-10 mixture, and placed into a plastic bag. PLEASE DO NOT USE BLEACH ON HARNESSES AND ROPES. Bleach is corrosive and will destroy the integrity of the equipment.
c. Once the harnesses are removed. The person being decontaminated stands facing the person with the bleach spray solution in a star fashion, with legs apart and arms outstretched to the side, eyes closed. The individual who has the spray bottle sprays from the top of head, working down the shoulders and the arms, including under the arms, the front of the body, down each leg, front, inside and outside, and the front of the shoes.
d. Then the person being decontaminated turns around, and the procedure is repeated from the top of head to under soles of shoes/boots as above. Working on the back, additional time should be spent spraying the soles of the shoes. The soles of shoes and boots pick up a lot of soil trapped in the treads SPECIAL CARE SHOULD BE TAKEN TO SPRAY THE SOLES OF THE BOOTS CLEAN.
e. Once this is completed the person who was sprayed down can assist others to be decontaminated, or move slightly away from the spray area and those not yet decontaminated, and remove their coverall.
f. PLEASE DO NOT REMOVE COVERALLS AND THEN ENGAGE WITH PEOPLE EXITING THE CAVE AS THEY CAN TRANSFER PATHOGENS TO YOU, SO YOU WILL THEN NEED TO BE SPRAYED DOWN IN WHAT YOU ARE WARINING be it your birthday suit. Keep a minimum of 5 m distance between contaminated and those to be decontaminated.
g. The coveralls that were removed can be placed in plastic holding bags (bin bag is fine) and a 10 % bleach is sprayed into the bag, before it is sealed (knot tied in the top). The additional application of bleach will allow for more of a vapour to be created in the bag, getting to decontaminate areas that were missed in the direct spraying (e.g. inside of the coverall). Also in our hot dry environment the initial spray may have dried and not had a minimum contact time of 1 minute. So we just take the extra precaution, for this reason.
h. The bag containing harnesses and ropes should be sprayed with additional F-10 solution, and the bag sealed/closed.

i. Both bags containing your gear, are then sprayed on the outside with a 10% bleach solution. This will then kill any pathogens that may have come into contact with the outside of the bag while you were handling it.
j. After about a minute these bags can then be placed into your vehicle for transportation home.
k. At home you can open the bag/s and remove the coverall and washed with normal detergent.
l. When at home rinse your spray bottle out with water and clean the nozzles. If the nozzle is metal, then the nozzle should be rinsed in a 70% ethanol (alcohol) or the F10 solution applied. This is to neutralize the corrosive nature of bleach on metal objects.

If a 10% bleach solution is sprayed onto metal objects (climbing ladder or carbine) then these metal objects need to be sprayed with 70% ethanol or F10 to remove the bleach. Bleach is a corrosive and will damage equipment if the bleach is not neutralized.

Ideally used coveralls should be stored in the decontamination bag with a 10 % bleach solution for a minimum of 1-12 hrs, and then washed in soapy water, and dried before re-use. However, this is not always possible.

Same cave multiple days

If the same cave is to be entered on multiple days then the decontamination procedure above is followed, but between excursions the coverall is kept in a decontamination bag for 1 12 hrs, after which the coverall may be removed and hung up to dry before being reused. Coveralls that are damp may be worn directly from the bag, however, check that you do not have an allergic skin reaction to the bleach solution. In the above situation we are not necessarily concerned about transporting microbes between caves, but more so from a human health perspective where we may infect a loved one or someone who comes into contact with you when you exit the cave.

Multiple caves same day

If more than one cave is to be entered during the same day, it is recommended a new coverall is used for each cave. To reduce the possible transfer of any pathogens/microbes coveralls should remain a minimum of 1 12 hrs in a decontamination bag before being used again in a new cave.

Particular care should be taken with the spraying down of boots (especially soles), if moving to a different cave.

In the case where the same harness and ropes are needed then this equipment should be allowed a minimum of 1 hour (contact time needed for F10 solution) in its decontamination bag before being used.

Decontamination of safety equipment

When you are back home, it is recommended that you soak harnesses and ropes in a 1:100 F10 solution for a minimum of 45 min, then air dried this will allow for any pathogens that may have had a deeper penetration into the equipment to be killed. This is especially important if you are going to be caving across distinct cave systems. Caves that are closer together may share similar microbial communities (but we don't know).

Future of cave conservation

In an ideal world it would be nice to have dedicated safety equipment (gear) for each cave. In some caves in the USA (e.g. Mammoth Cave) this precaution has been taken by cavers. There may come a time where as cavers you feel that X cave/s have something special and we should take extra care not to destroy it. Only you as a community will know which caves these are and can take the appropriate

measures to ensure its conservation and preserve its integrity. Dedicated equipment may be purchased for these specific caves and stricter measures, such as decontamination before entering the cave is considered.

As our knowledge and understanding grows, as a responsible caver so we should change our past behavior's and methods so as to minimize future threats, even if they are small.

As the old saying goes, *"leave only footprints behind"*, but should be amended to state don't leave any unintentional pathogens either behind.