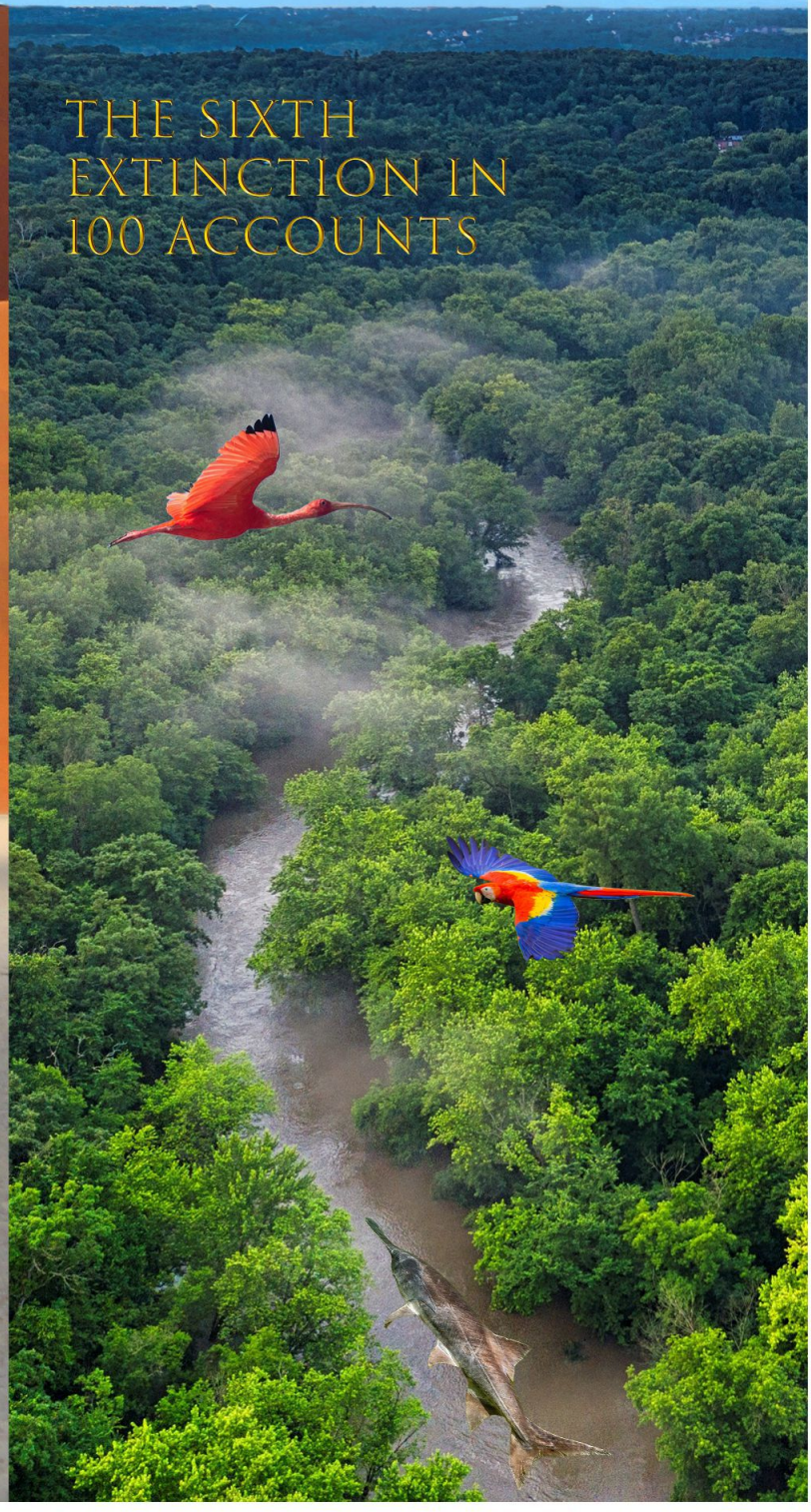
WHAT'S LOST AND WHAT REMAINS

THE SIXTH EXTINCTION IN 100 ACCOUNTS



Branden Holmes

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FIRST EDITION

https://recentlyextinctspecies.com

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Preface

When I began slowly writing this book some years ago many of the plants and animals included were little known. In the intervening period some of these have been plucked from obscurity due to books, magazines, websites, news stories, social media, etc. Which can only be a great thing from the point of view of conservation biology, raising awareness about the plight of organisms that typically receive less attention and not from lack of merit. But it does make it harder to write a volume that merits publication.

Each account is centred around a single species, but invariably combined with a broader review of multiple species with something important in common. The result will hopefully be a more robust understanding of the current biodiversity crisis by the reader. And a greater appreciation of the diversity of the natural world more generally. Having recently lost so much biodiversity already, it is critical to bring attention to the incredible array of species that survive, and hence the need to protect them now more than ever.

I struggled with whether or not to use the phrase “Sixth Mass Extinction” in the title or subtitle of the book. As it currently stands, we have not lost more than three-quarters of all species on Earth within a geologically short period. Yet, the current trajectory of biodiversity loss is sadly on track to do so. So, for the purpose of retrospect, and to make it easier for people to find this book, I have decided to use the phrase.

There are no maps included with the book, even though many obscure places are mentioned. And despite both the availability of free images on the internet and their value in helping people visualise, no photos are included either. I hope this will motivate the reader to research these things for yourself. Unlike other subjects, the risk of writing a book so complete that the reader puts it down and never revisits the subject is too great. This book is designed to whet your appetite, not satiate you.

Introduction

The human body is a paradoxical combination of resilience and fragility. This can lead to unimaginable suffering as what should have killed someone may not even render them comatose. I was 15 years old when my grandfather had the second biggest stroke his doctor had ever seen. It went right down the back of his neck, leaving him in a state of trapped consciousness for the few short weeks before his death in 2004. The first time I visited him in that Kalamunda hospice he was strapped down in a cruel irony for his own safety. The second and final visit was even worse. He was sat in his chair, pitifully attempting to put a knitted blanket on himself. He never responded to my voice, never gave any indication that he was even aware of my presence. In an all too cruel sense that midnight phone call was superfluous. But at least he lived to be a grandfather.

One of the many tragedies of life is that most of us are lucky to be out of our teens before we know somebody from our own age group that has died. Or worse, we experience a sibling pass away and grow up wondering what they would have been like as an adult. An extremely premature death by any serious measure given that we are one of the longest-lived mammals, indeed of all animals. But there is a far more serious and overt kind of premature death looming: that of whole ecosystems.

A sexually mature male Siberian tiger (*Panthera tigris altaica*) lives an invariably solitary life, resiliently walking hundreds of kilometres in a freezing, snow-laden environment. Apart from brief periods of reproduction, he lives, hunts and dies alone. But he also lives in a forest that is teeming with other species. He relies upon them, just as they rely upon him, in a mutually beneficial relationship. But due to us humans there is now an extra fragility to life.

Already vulnerable due to being a top predator confined to a single island, nothing in the evolutionary history of the Bali tiger (*Panthera tigris balica*) could have prepared it for the hunter's rifle. This trophic cascade, as the top predator was removed from the food chain, could easily have caused a proliferation of herbivores that chewed through the island’s vegetation one species at a time. Depriving pollinators of their ecological role among other terrible effects. The fact that no such plants are actually thought to have become extinct on Bali as a result does not mean that none did in fact become extinct. And if they did, it would be just as great a loss as that of the Bali tiger.

But there is a more precarious sense of loss at play here too. Canadian forester Josh Noseworthy came up with the Jenga analogy of species loss within an ecosystem. Even if you're somehow unfazed by the extinction of plants, removing those Jenga blocks (i.e. plants) from the tower (i.e. ecosystem) weakens the overall structure. It pushes the ecosystem closer to collapse. But the tower could also fall due to external forces as well, such as a wonky table (environmental changes). Or worst-case scenario, that first Jenga block removed really does bring the whole tower down by itself. But it seems to me that the threat here is even worse. It is fine to talk about Jenga towers independently of each other, but ecosystems aren't so easily

demarcated in reality. They are connected in ways that we probably cannot even comprehend (yet).

As some of the accounts in this book will help to bolster, actually confirming extinction is often very difficult. That is, the systematic death of all of the individuals of a population, subspecies, etc. But such a concept as absolute extinction is not in fact the truly relevant one. Rather, functional extinction is the key concept here. For it is the true point of no return. After all, a sexually reproducing species with only a single extant individual is in no better position to persist >0 number of generations into the future than a completely extinct species. Though this ignores the advent of conservation cloning and so-called "de-extinction", which will be addressed soon.

But even genetically healthy species can fail to constitute a viable population. The classic example of this is the Kakapo (*Strigops habroptila*), a New Zealand parrot which in 1976 had been reduced to only 18 males. It was only the discovery of a sexually diverse population on Stewart Island that, at least to our knowledge, saved the species. While the seeds of the Jellyfish tree (*Medusagyne oppositifolia*) never germinate in the wild on Mahé in the Seychelles. It's only due to the *ex situ* germination of seedlings in highly controlled conditions that the species has any hope of survival. And in a tragic irony, the most recent global extinction known was the Dusky-apex Oahu tree-snail (*Achatinella apexfulva*), a Hawaiian land snail which despite being a hermaphrodite could not reproduce individually. And thus George, as the "endling" or last member was called, passed away on New Year's Day in 2019.

But the problem is even worse. Quantifying extinction based upon the loss of species does not include every kind of biodiversity loss. So that mass extinctions extend far beyond their temporal setting. It is certain that no matter what, we will be responsible for the extinction of many species even after we've become extinct ourselves. Their future failure to adapt to changing environmental conditions due to the loss of genetic diversity because of us innumerable generations prior.

Even worse still, the current biodiversity crisis actually started deep into the Late Pleistocene (126ka–11.7ka). It is hard to fathom just how much biodiversity we have lost over those more than 100,000 years. And while it is possible to try and quantify extinction rates, unsurprisingly numbers fail to tell the real story. It lacks nuance and fails to provide a deeper analysis of what is truly going on.

It might seem strange to cover many species that survive in a book about extinction. There are four basic reasons for this. Firstly, such species can help inform us of the cause of the extinction of other species. A rare species persists while a common species declines to extinction. Secondly, many of the organisms covered in this book, though they survive, were feared extinct at some point. And thus, the cause of their previous declines absolutely has importation for conservation biology. Thirdly, and in the opposite direction, the causes of extinction have importation for species that are still extant. It can help us to predict what threats living species may face, both now and in the future. And fourthly, and perhaps most importantly, it attempts to highlight the great amount of biodiversity that still remains. Given how much biodiversity we have lost, it becomes even more important to appreciate and conserve that which still survives.

But I've left the two most important messages for last. I want to see a Woolly mammoth (*Mammuthus primigenius*) just as much as anybody. And if the resurrection of the species is ever achieved, it will truly be one of the greatest human feats ever accomplished (and the work of innumerable researchers). However, conservation cloning is *not* a solution. It is hard to get across just how many species and subspecies are known from a handful of specimens, often collected accidentally or serendipitously. So that there must be so many more organisms which have been lost without us knowing it. And with none of their DNA we cannot bring them back. Moreover, there is little genetic diversity (or no DNA, depending upon the method of preservation) from even many of the museum specimens we do have. We cannot reverse even a tiny proportion of the actual loss we have inflicted. The belief that we can simply bring back species at will, in the future even if not now, is the single most dangerous idea in conservation biology.

Secondly, ideally conserving a species means conserving its habitat, and that hopefully means protection for other species too. Not just those that we know about, but those that remain undiscovered. And you can bet that there is still so much to discover on Earth. In its forests, rainforests, deserts, lakes, rivers, brooks, seas, oceans, scrub, woodlands, grasslands, steppes, tundras, caves, and on and on. Forget space, the Earth is an alien world if you look hard enough. Or read on.

Short Note

There is a growing body of evidence which suggests that there were six, not five, mass extinctions in the geological past. If true, this would mean that the current biodiversity crisis, often referred to as the "Sixth Extinction", would in fact be the “Seventh Extinction”.

The 100 Accounts

1. What colour is the Giant panda? (*Ailuropoda melanoleuca qinlingensis*)

There are actually two subspecies of the Giant panda (*Ailuropoda melanoleuca*). The iconic black and white animal immortalised as part of the World Wildlife Fund (WWF) logo is the nominate or first subspecies described (*A. m. melanoleuca*). On the other hand, the Qinling panda (*A. m. qinlingensis*) confined to the Qinling Mountains is *brown* and white. In fact, it was only discovered in the 1960's, and even then, it was only scientifically described in 2005 (Wan *et al.*, 2005). Moreover, while the WWF logo was created (1961) before the Qinling panda was recognised, it is ironic that it hasn't been re-coloured since the latter is much rarer (1,500–3,000 vs. 350–400).

There is also a misconception that giant pandas have very low fecundity, requiring captive breeding to sustain their population. If this were true the species would never have evolved. In reality, a lack of mate choice under *ex situ* conditions is to blame. While one fossil subspecies, *A. m. baconi* (Woodward, 1915) became extinct during the Late Pleistocene (126ka–11.7ka), though the reason/s for its demise are currently unknown. It was for decades only known from a single cave site in Myanmar (formerly Burma), well outside the species' current range. And was considered a full species in its own right. But it has now been found in northern China too, and with this greater amount of comparative material available, it has been reduced to a subspecies of the extant Giant panda (Liang *et al.*, 2020).

While the brown and white Qinling panda is not in immediate danger, several colour morphs of other species have become extinct during the late 19th and 20th centuries. A dark colour morph of Milne-Edwards's sifaka (*Propithecus edwardsi holomelas*) was last reported in the late 1800's from Madagascar, although some consider it a valid subspecies (Groves & Helgen, 2007; Wright *et al.*, 2020). The Faroe Islands were home to the Pied raven (*Corvus corax varius* morph 'leucophaeus') until the last one was shot in 1902 (van Grouw, 2014). While the Cape red hartebeest (*Alcelaphus buselaphus caama* morph 'caama') was saved from extinction for many years by the Moe brothers on their South African farm, but its sale in 1938 doomed the colour variant (Harper, 1945).

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2. The bird that couldn't go extinct? (*Phyllastrephus leucolepis*)

A pre-requisite of extinction is prior existence. Ideally then, conservationists today would have access to the best taxonomic resources which would not result in them putting effort into trying to save (sub)species which never existed. But due to the relatively recent advent of DNA analysis, and older species concepts that revolved largely around morphology, there are many mysterious specimens in museums collected over hundreds of years. These may simply turn out to be mutants/aberrants of known (sub)species (e.g. Black boubou *Laniarius liberatus* (Nguembock *et al.*, 2008)), hybrid individuals displaying unique morphology (e.g. Elliot's bird of paradise *Epimachus ellioti* (De Vos, 2017)), or they may represent missing/extinct (sub)species (e.g. Brace's emerald *Riccordia bracei* (Graves & Olson, 1987)).

One such case is that of the Liberian greenbul *Phyllastrephus leucolepis*, a songbird from Liberia's Cavalla Forest in West Africa. Between 1981–1984 ornithologist Wulf Gatter observed one or two birds that differed in their plumage from the widespread Icterine greenbul (*P. incterinus*). He collected one of the specimens in January 1984, which served as the basis of the new species (Gatter, 1985). But the bloody Liberian civil war (1989–2003) ensured that no further attempts could be made to look for this newly discovered species until 2010 and 2013. But neither attempt succeeded, and later genetic testing showed that the Liberian greenbul is almost certainly merely a "plumage variant" of the Icterine greenbul (Collinson *et al.*, 2017). While there are many other museum specimens that await further analysis, and perhaps even better techniques for sequencing smaller amounts of DNA. But unless there is enough viable DNA left to test, they may sit in a drawer forever, their true identity a perpetual mystery.

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3. From rediscovered to common pet in 20 years (*Correlophus ciliatus*)

Most species or subspecies that are rediscovered have a very low population, which is often part of the reason that they disappeared without record for a long period. But as long as the rediscovered population is viable there is the potential for it to bounce back. One such truly extraordinary case is that of the Crested or Eyelash gecko (*Correlophus ciliatus*) (Guichenot, 1866) which disappeared from New Caledonia around 1870, and was then rediscovered in 1994 after a storm (Seipp & Klemmer, 1994). Yet due to its hardiness (and cuteness!), it is today one of the most widely-kept geckoes in the world. They can cost as little as US$85 depending on the size, and there has been a book available on keeping the species in captivity for more than a decade (Hamper, 2005).

Upon their rediscovery, prior to the export of animals from New Caledonia being banned, captive populations were established for scientific research. These quickly made their way into the wider herpetology market where they remain a popular choice for beginner (and more established) keepers. This situation may be very fortunate, as it has likely resulted in less incentive to poach animals from the wild, which suffer threats such as an introduced ant (*Wassmania auropunctata*). Unfortunately, other rediscovered species such as the Chilean stage beetle (*Sclerostomulus nitidus*) have not been so lucky (Crespin & Barahona-Segovia, 2020).

Happily, the Terror skink (*Phoboscincus bocourti*) which also disappeared around the same time (c.1872) from "New Caledonia" was rediscovered in 2003 on the offshore islet of Île des Pins (=Isle of Pines) (Caut *et al.*, 2013). Unfortunately, an undescribed goanna (*Varanus* cf. *indicus*) which was also known from New Caledonia is now thought to be extinct, with the last known individual killed by a car around 1970 (Balouet, 1991).

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4. The Frosted phoenix hasn't been seen since 1959 (*Titanomis sisyrota*)

The Frosted phoenix (*Titanomis sisyrota*), a missing moth from both of New Zealand's main islands, was given its common name by scientist Robert Hoare in 2001 (Hoare, 2001). He hoped that a common name would help raise public awareness about the species, since there are few lepidopterists working in New Zealand. If only a few scientists are on the lookout for the species then it is unlikely to be rediscovered even assuming that it still exists.

It is known from ten specimens (two now lost) collected between the 1870's and 1959. All were of single records like the real Phoenix. Unfortunately, as a rather average sized moth of rather standard colouration, a member of the public may not immediately recognise one unless they were trained to distinguish it from other species. Even though it is the only species in its genus (*monotypy*), and possibly even family, and thus actually morphologically quite unique. Hence the need for a publicity campaign.

A similar fate threatens Douglas' broad-headed bee (*Hesperocolletes douglasi*) from Western Australia. Originally known from a single male specimen collected on Rottnest Island sometime between 9–12 November 1938 (Michener, 1965), it disappeared for many decades and was even thought to be extinct (Burbidge, 2004). The present author contacted the Western Australian Museum in 2014 about a publicity campaign, with very positive results (Houston, 2014) that helped lead to the rediscovery of the species the following year (Dr. Terry Houston, *pers. comm.* 17 September 2018; Pille Arnold *et al.*, 2019).

However, as many of the defining characteristics of the species appear individually in other species, identification of this species truly requires an expert. Hence, it will probably only be through immense luck that we may yet learn much more about the species in the short term. And not knowing its geographical distribution or ecology makes it extremely difficult to put conservation measures in place.

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5. You can count this palm with your palm (*Hyophorbe amaricaulis*)

On the island of Mauritius east of Madagascar grows a 12m (39.4ft) palm. To the ordinary person it looks like every other palm in the grounds of the Curepipe Botanic Gardens. Surrounded by a supporting metal frame almost as tall as the plant itself, only the wire fence around it gives any indication of its value: it is the last of its species on Earth.

The Loneliest palm (*Hyophorbe amaricaulis*) was scientifically described in the late 1700's and unsurprisingly appears to have been rather common at the time. But confusion with the closely related Bottle palm (*Hyophorbe lagenicaulis*) meant it was largely overlooked. Indeed, it was thought extinct until 1942 when the current specimen was recognised during a palm survey. Attempts to propagate it have so far failed, but that's no reason to give up hope.

A similar, though happier, situation has befallen the tree species *Madhuca diplostemon* from the Kollam District of Kerala, India. Kerala's sacred groves are patches of remnant vegetation protected because of religious beliefs, and have undoubtedly contributed to the survival of a number of species (Nair & Mohanan, 1981; Jagadeesan *et al.*, 2015).

It was rediscovered in one of these groves after 184 years (Shailajakumari *et al.*, 2020), but only a single mature tree was found despite extensive searches. A wooden sign near the tree indicates that it was confused with a more widespread congener (*i.e.* a member of the same genus), and that further individuals were likely destroyed in the process of temple expansion. Thankfully, it has been possible to propagate the species using seeds from this individual, and so it has been saved from the same slow march towards extinction that the loneliest palm on Earth is facing.

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6. Beefing over extinction dates (*Bos primigenius*)

The wild ancestors of most domesticated animals are still extant, but some have gone extinct. The Aurochs (*Bos primigenius*) was the direct ancestor of many of today's cattle breeds, standing an imposing six feet at the shoulder. They would have been a truly formidable foe for any prehistoric humans (whether *Homo sapiens*, Neanderthals, or Denisovans) who wished to hunt a herd, let alone tried to capture them alive for domestication. Understandably, the imposing animals were depicted in ancient European cave art at Lascaux (France) and other places.

The last bull was said to have been killed in 1620, and the last female in Poland's Jaktorów Forest in 1627. However, recent genetic testing of the last known male found that he was not a pure Aurochs (Bro-Jørgensen, 2018). This suggests that the last female was also not pure, and hence the Aurochs' extinction chronology will need to be revised in the earlier direction.

A similar problem engulfed the Tarpan (*Equus ferus*) for many years, long considered the putative ancestor of domestic horses. It was allegedly the last true wild horse after the extinction of a dozen other Eurasian and American species during the Late Pleistocene–Holocene (e.g. Villavicencio *et al.*, 2019; Yuan *et al.*, 2020). It was debated whether the population had been hybridised out of existence by the late 1800's or whether they persisted into the 20th century (Groves & Grubb, 2011). But a very recent study found the Tarpan to be a result of domestication, with the true ancestors of today’s domestic horses originating from the Western Eurasian steppes (Librado *et al.*, 2021).

Starting with the Heck brothers (Germany), attempts have been made to "breed back" both the Aurochs and Tarpan although the results are ambivalent. These experimental animals can be seen on many European farms today, only broadly resembling their respective counterparts. The other, arguably more successful, back breeding project has been that to bring back the *phenotype* (physical appearance) of the Quagga, a South African zebra that possessed relatively few stripes compared with a “typical” zebra (Barnaby, 1996; De Vos, 2014).

While the enigmatic Kouprey (*Bos sauveli*), a wild cattle species from Cambodia only recognised by western science since 1937 and last recorded in 1969, was the subject of an intense debate during the early 2000's. In a series of scientific papers (e.g. Hassanin & Ropiquet, 2007; Hedges *et al.*, 2017), the idea that it may simply have been a feral hybrid (Galbreath *et al.*, 2006) was strongly refuted. It is one of relatively few extinct species for which photos of both living and recently killed animals are known, as well as an extraordinary colour film of a Kouprey herd taken in 1951 by Cornell University’s Dr. Charles H. Wharton.

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7. Sea the rise of climate change (*Melomys rubicola*)

Bramble Cay is a mere 4ha (9.88 acres) in size within the Torres Strait. It is 55km (34 miles) south-east of New Guinea, and 45km (28 miles) north-northeast of the human-inhabited Darnley Island. And it is just about the last place on Earth that you would expect to find a terrestrial vertebrate, as low vegetation covers only a small proportion of it. Yet the endemic Bramble Cay melomys (a rodent), which diverged from its closest known relative some 900ka, called the cay home until at least 2009 (Gynther *et al.*, 2016). But not even this incomprehensibly hardy rodent could survive the effects of climate change on such low terrain.

Ocean inundation has slowly won out over deposition on the constantly shifting cay. Its vegetation cover slowly shrank over the course of two decades, squeezing out the species until exhaustive surveys confirmed the worst (Gynther *et al.*, 2016). No translocation or captive population was ever attempted, despite being found nowhere else and with a documented decline since at least 1983. Although the species has been suggested as possibly surviving in the Fly River region of New Guinea (Gynther *et al.*, 2016). Two lesser-known victims of climate change were formerly found in the Seychelles, a snail (*Pachnodus velutinus*) last recorded in 1994, and a goby (*Asterropteryx gubbina*) last recorded in April 2008 (Gerlach, 2010).

Unfortunately, much of the land area in the Torres Strait is likewise very low-lying and hence equally susceptible to the effects of climate change. From satellite photos, Poruma (=Coconut) Island looks like a developed paradise supporting a thriving indigenous community, with a runway ensuring supplies can be brought in quickly and safely. But the truth is far darker, as the island is slowly being washed away by king tides.

Attempts are being made to save the island for its inhabitants, the indigenous people and their ancient culture. But it is very expensive work far beyond the means of the small economy of the island. It requires millions of dollars in external funding from the Australian Government that is ultimately probably only delaying the inevitable. To say they are a people with a very uncertain future is an immense understatement (Hegarty, 2020).

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8. The frog whose babies crawl out through the mother's skin (*Pipa pipa*)

The male Suriname toad (*Pipa pipa*) doesn't croak. Instead, he attracts a mate by snapping a bone in his throat. The interested female then births her eggs in the water which he duly fertilises. The male's swimming then helps the eggs become imbedded in the female's back. These eggs slowly become absorbed into the skin, until the buried toadlets are fully developed and ready to hatch. They then make their way to the surface through the skin on her back and push out into the world. Leaving the mother's back looking like a crumpet (griddle cake). She then sheds the damaged skin ready to do it all over again. The same basic mode of reproduction is known in its close relative, Arrabal's Suriname toad (*Pipa arrabali*).

Indeed, frogs and toads (anurans) have a surprisingly diverse array of reproductive modes (e.g. Hödl, 1990). But with the spread of Chytridiomycosis (caused by the funguses *Batrachochytrium dendrobatidis* and *B. salamandrivorans*) driving their declines and extinctions globally (Skerratt *et al.*, 2007; Feldmeier *et al.*, 2016; Rahman *et al.*, 2021), entire reproductive modes (shared by multiple species) are being lost. During the 1970's–1980's, two extraordinary frogs were scientifically described and then simply disappeared. The Southern gastric-brooding frog (*Rheobatrachus silus*) and the Northern gastric-brooding frog (*R. vitellinus*) were found in Queensland, Australia. The first and only frogs known where the mother incubates the tadpoles in her stomach (Tyler, 1984).

While in Chile and Argentina a precariously similar fate threatens another pair of unique frogs. Darwin's frogs, *Rhinoderma rufum* and *R. darwinii*, are the only known mouth-brooding frogs with the male caring for his young in a special oral sac. The former species is now thought to be extinct, last recorded in 1978 or 1980. While the latter has mysteriously declined and is seriously threatened with extinction (Soto-Azat *et al.*, 2013). Amazingly, at least 23 new species of frogs have been described in 2021 alone, indicating that the group's true diversity is far from being fully discovered yet (e.g. Garg *et al.*, 2021; Günther & Richards, 2021; Mahony *et al.*, 2021).

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9. A pest in its own land? (*Levuana iridescens*)

Any gardener knows how frustrating weeds can be, to the point that it's hard to imagine them being innocuous in their natural habitat. Thus begins our introduction to the Levuana moth (*Levuana iridescens*), an historical pest of coconut palms (*Cocos nucifera*) on the Fijian island of Viti Levu from the 1870's until a successful biological program in the mid-1920's. It is probably now extinct there (last specimen collected in 1941), while another putative victim of the biological control program, *Heteropan dolens* (also a moth), was later rediscovered on Aneityum Island, in Vanuatu (Hoddle, 2006). The thing is, it has never been recorded outside that single island (excepting its later spread to offshore islets), mirroring the case of *Neocnemis occidentalis* (Stüben, 2019).

Was it the proliferation of coconut plantations that naturally increased the moth's food supply and hence their numbers exploded to pest levels? Or does its true biogeographical origin lie elsewhere in Fiji, or even outside the islands? It is a question that has long been debated because of the possibility that an endemic species may have gone extinct (Hoddle, 2006). The most recent study of the species, which utilised DNA to uncover its evolutionary relationships (Nazari *et al.*, 2019) only deepened the mystery. They found that *Levuana iridescens* is most closely related to the four known species of the Australian genus *Myrtartona*, but it is definitely distinct from them at the genus level. The fact that it is both the only member of its genus and not recorded elsewhere suggests that it is native to Viti Levu (and thus possibly endemic).

The lack of records of the species on the island prior to the 1870's, and the subsequent lack of records, may be more to do with improper search methods. Only twice a day do the coastal winds die down for half an hour, which is the time when the diurnal moth would presumably be most active (Nazari *et al.*, 2019). Yet these windows have not previously been actively utilised in the search for the species. If it does still exist, assuming it is native (even if not endemic), it may not ensure the species' conservation given its historical status as a pest on a commercially lucrative plant. Sometimes reputations, whether positive or negative, outlast research.

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10. The lingering smell of extinction (*Santalum fernandezianum*)

Three extinct species of plants from two continents had the smell of their flowers recreated through their DNA for global travelling exhibitions starting in early 2019. The Maui hau kuahiwi (*Hibiscadelphus wilderianus*) from Mount Haleakalā, Maui, Hawaii. The Falls-of-the-Ohio scurfpea (*Orbexilum stipulatum*) from Rock Island in the Ohio River, Louisville, Kentucky. And the Wynberg conebush (*Leucadendron grandiflorum*), from Wynberg Hill, Cape Town, South Africa. However, not all plants lose their smell after extinction.

The Chile sandalwood (*Santalum fernandezianum*) was endemic to the Juan Fernández Islands (Chile), and was cut down for its aromatic wood. The last tree was seen and photographed in English Harbour in 1908 by botanist Carl Skottsberg (Skottsberg, 1910), one of very few photographs of an extinct plant prior to the new millennium. You can clearly see that many of its branches had been cut off for its prized wood. Remarkably, it can still be aromatically encountered even today, as wood fragments on the island's forest floor still retain their fragrant smell more than a hundred years later (Baeza *et al.*, 1999).

There are about 25 other recent species in the genus *Santalum*, including the well-known Indian sandalwood (*S. album*) which has been harvested for centuries. The latter is used to produce sandalwood oil which commands a very high price. But thanks to its extensive distribution, unlike the insular *S. fernandezianum* which was confined to a tiny area, it is "only" threatened with extinction. Many of the members of the genus are root parasites, which steal water and nutrients from other trees via their roots, though they can freely photosynthesise on their own. Whether the Chile sandalwood was likewise a botanical thief is unclear. Sadly, its branch on the Tree of Life was all too literally cut off before it could be properly studied.

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11. Us humans (*Homo* sp.)

Given our immense success in colonising the planet, and now aiming for space, it is easy to view ourselves as utterly unique (whether good or bad). The fact that we are also the undisputed architects of the current biodiversity crisis clearly serves as a warning that our intelligence is at best a double-edged sword. This leads us to consider the place of the other members of our genus which survived until at least the Late Pleistocene (126ka–11.7ka) but have since become extinct.

It is well known that inter-breeding with Neanderthals and Denisovans, and possibly a third mystery species (Mondal *et al.*, 2019), contributes around 2–3% of our DNA. Lesser known is that another three or four other human species may have also existed during this period (Boaz & Ciochon, 2004; Brumm *et al.*, 2018; Sutikna *et al.*, 2018; Détroit *et al.*, 2019). Thus other human species existed over much of the planet while we were still confined to Africa but are now long gone. Our uniqueness among living species is thus ultimately rather artificial, not least given the intelligence displayed by Orangutans, Gorillas, Chimpanzees and Bonobos.

Given that most if not all of these human species would have been of comparable intelligence, our survival and their demise appear to be more to do with luck. Even if we are implicated in the extinction of Neanderthals (Shipman, 2015). That most if not all of these other species of humans used tools is completely unsurprising, making it easier to hunt and thus negatively affect animal populations. Yet there is very little evidence that any other human species drove even a single species extinct.

There is a tenuous position espoused by some scientists that ancient humans drove African megafaunal mammals extinct millions of years ago, long before our species (*Homo sapiens*) arrived on the scene. But there is no good evidence to suggest that this is actually true (Faith *et al.*, 2020). Leaving open the possibility that we alone, of all human species throughout history, are uniquely destructive. Though the more obvious and plausible reason is that the demise of all the other human species equated to far less competition, allowing us to thrive, which in turn allowed technological innovations that allowed us to travel across the water to islands where we could hunt insular species that had evolved in the absence of predators.

Our global domination has been great for us as a species, but it has been terrible for the planet. And it doesn’t do much to point out that we haven't been responsible for every single recent extinction (see No. 14). The fact is that we are both responsible for the current biodiversity crisis, and have the single greatest influence over its future trajectory. So what can you as a reader do about this? Simply by having a garden and planting it with native species, you help promote the flourishing of native animals in your area. Or if you don’t have room, strongly suggest to your friends and neighbours that they choose natives over exotics. Slightly reversing at a local level the global trend of species declines globally. The future is in all of our hands, so do your bit.

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12. The Greyhound pig made a better jumper than a sheep (*Sus scrofa domesticus*)

Today's domestic pig breeds are not particularly known for their agility. This is in stark contrast to early modern breeds that were closer to the wild type, a far cry from contemporary porkers. This includes the extinct Greyhound pig from Ireland: a long-legged, narrow-backed, long-snouted breed with pendulous throat wattles. According to one 1857 source they were capable of clearing a five-barred gate (Richardson, 1857). This equates to around 1m (3.3ft) high which seems rather extraordinary. And while it might be a slight exaggeration, they were no doubt known for their jumping ability. Just as domestic pigs in general are known for being highly intelligent and caring creatures which need sufficient space and adequate food and shelter. And suffer greatly, often dying extremely prematurely, if kept by themselves.

Turning to a more literal comparison with sheep, archaeological excavations at the Peruvian site of El Yaral uncovered the mummified remains of Prehispanic Llamas and Alpacas. In fact, two previously unknown breeds of each (all presumed extinct) were found. Analysis of their fleece fibres found that their quality was much better than that found in South American camelids today (Wheeler *et al.*, 1992). As with other archaeological findings from the continent, the controlled breeding of animals for increased fleece quality indicates just how advanced these civilisations were. Until the conquest which destroyed or scattered their societies, and undid all of their careful breeding.

In North America, the Amerindians did not have ready access to such finely woolled herbivores. Instead, they improvised and developed at least two breeds of dog that they grew for their wool (McKechnie *et al.*, 2020). The introduction of sheep hastened the latter's demise as the demand for them waned.

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13. Half owl, half...owl (*Ninox novaeseelandiae undulata*)

Ideally conservationists want to maintain a viable wild population of every plant, fungus and animal, including sufficient habitat to support an increase in population. But as conservation measures are often late in the decline process, it is sometimes necessary to defer to extreme measures in order to prevent the loss of genetic diversity. The most extreme of these is to establish a hybrid population that essentially renders the (sub)species extinct via deliberate hybridisation which thereby retains a significant genetic legacy. In certain cases, it may be possible to carefully breed back a relatively pure population from these hybrids. Such as that being attempted with Giant tortoises from the Galápagos Islands (Quinzin *et al.*, 2019), and has been proposed to save the functionally extinct Northern white rhino (*Ceratotherium simum cottoni*).

The Norfolk boobook (*Ninox novaeseelandiae undulata*) was endemic to Norfolk Island (675km south of New Caledonia). Habitat destruction and selective logging of mature trees from remaining habitat meant that nesting sites were exceptionally rare. Consequently, the subspecies was reduced to a single individual, a female, by 1986. In a last-ditch effort to save the subspecies, two males of the genetically closest living subspecies, *N. n. novaeseelandiae*, were introduced onto Norfolk Island in September 1987 (Olsen, 1989). Successful breeding between the female and one of the two males has produced a viable hybrid population, whose mitochondrial DNA is pure *N. n. undulata*, and approximately half of whose nuclear DNA is also *N. n. undulata*.

Due to this close genetic affinity of the hybrid population to *N. n. undulata*, Garnett *et. al*. (2011) proposed that the subspecies be moved from "Extinct" to "Critically Endangered". Whereas if the last Norfolk boobook had been a male, his mitochondrial DNA (mtDNA) would have been diluted by that of the other subspecies brought in, rendering the population closer to 1/3 Norfolk boobook. Ideally, the subspecies would have been saved much earlier, with such fractional comparisons being superfluous. But faced with a single extant individual conservationists did the only responsible thing they could: they saved as much of her DNA as possible.

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14. One of the only recent natural extinctions was a cockroach (*Lucihormetica luckae*)

Cockroaches are maligned the world over as dirty pests that can survive large doses of radiation and are otherwise impervious. And it doesn't help their cause to know that their closest living relatives are termites (together they compose the insect order Blattodea). It is ironic then that one of the only probable recent extinctions not attributable to humans was of a cockroach. In 1939, the sole specimen of Lucka's bioluminescent cockroach (*Lucihormetica luckae*) was collected from Tungurahua volcanoe, Tungurahua Province, Ecuador. It then sat in a museum drawer for many decades until researchers recognised its uniqueness.

It was described as a new species in 2012 as the first known case of mimicry in a bioluminescent animal (Vršanský *et al.*, 2012). Though the claim of bioluminescence has since been scaled back to autoflourescence (Vršanský & Chorvát, 2013). Unfortunately, it's only known location was destroyed by a volcanic eruption on 5 December 2010, and attempts to find it again have since failed. Though the mouse *Apomys sacobianus* was rediscovered after a volcano eruption on Luzon (Heaney *et al.*, 2014), so some hope theoretically remains for the species. The year after *Lucihormetica luckae* was scientifically described, the Californian millepede *Xystocheir bistipita* was rediscovered and discovered to be bioluminescent (Marek & Moore, 2015).

In actuality, most species of cockroach (c.4,400 species) are rather harmless, and certainly not "dirty". In fact, the Giant burrowing cockroach (*Macropanesthia rhinoceros*) from Queensland, Australia, are popular pets around the world. They are the heaviest (<35gm) species, and also one of the largest (<80mm), and cannot fly. They dig burrows up to a metre (3.3ft) deep and live up to 10 years in captivity. This makes them an ideal choice for parents whose children want a pet, but also want to ease them into looking after an invertebrate before moving up to a dog or other larger animal that requires more care. They thus help teach children both responsibility and the importance of all life. Only giving a low hiss if agitated (they do not bite). And most of all they are incredibly endearing animals.

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15. A lone survivor (*Encephalartos woodii*)

Cycads are renowned as dinosaur plants, having been around for hundreds of millions of years. But their wild numbers are in danger from traditional medicine gatherers and illegal plant collecting. Members of the genus *Encephalartos* have been particularly affected, with seven species possibly or definitely extinct in the wild. And an undescribed species (*Encephalartos* sp. Greenway 6283) only known from a single herbarium specimen collected in 1941 from the Miombo woodland in southern Malawi, an area now completely transformed. Luckily, the other species in the genus known from a single wild plant has a happier story.

Wood's cycad (*E. woodii*) was discovered by Durban Botanic Garden curator John Medley Wood (after whom the species is named) in 1895, in the Ngoya Forest (now the oNgoye Forest). A single male plant with multiple offsets and trunks was found, and over the period 1899-1916 every part of the plant was removed from the wild and sent to various botanical gardens around the world for its safety (Donaldson, 2009). One of the last two wild trunks had fire and trunk damage from bark harvesting for Zulu traditional medicine. Most pieces survived long enough to produce further offsets, and an original trunk from the sole known wild plant can still be seen in the Durban Botanic Garden today. Though there has also been some debate about the validity of the species (Viljoen & van Staden, 2006).

Unfortunately, traditional medicine is not the only threat that cycads now face. Despite often being largely omitted from talk of the current extinction crisis, the global plant collecting community is very large, with some individuals willing to spend big for rare and exotic plants. And while most of this activity is quite legal, including export permits for international trade, criminal activity is rife in South African cycads (Torgesen, 2017).

Another genus hard hit by illegal plant collecting is *Nepenthes* in Asia, better known as Pitcher plants or Monkey cups. An extraordinary group of carnivorous plants (family Nepenthaceae) that feed on small animals, usually invertebrates. There are currently around 170 known species, although many more are yet to be described. But if the current rate of wild collecting continues, many may go extinct before they are ever encountered in the wild by botanists. Almost a dozen have already had to be rediscovered in the wild (e.g. McPherson, 2021). Thankfully, they propagate readily via tissue culture, relieving pressure on wild populations.

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16. The Komodo dragon is a dwarf? (*Varanus priscus*)

The Komodo dragon (*Varanus komodoensis*) lives on four Indonesian islands (Komodo Island, Flores, Gili Motang and Rinca), and was only "discovered" by Western scientists in 1910 despite its enormous size. An authenticated specimen measured 3.13m (10.3ft) and weighed 166kg (366lbs) after a large meal (Ciofi, 1999). And while there are a few other species in the genus (*V. salvator*, *V. salvadorii*, *V. giganteus*) that approach the Komodo dragon in length (6–8ft long), they are all far more lightly built. Fossils indicate that the Komodo dragon actually evolved in Australia, and was only a medium-to-small member of a group of giant varanid lizards (all >3m total length) that have otherwise become extinct (Hocknull *et al.*, 2009, 2020).

The largest of these, Megalania (*Varanus priscus*), is estimated to have measured between 5.5–7m (18–23ft) long and weighed somewhere between 575–1,940kg (1,268–4,277lbs). Although given the inherent problems extrapolating overall size of an animal from a few bones, these estimates are perhaps better seen as representing outsized (*i.e.* the biggest) individuals. While evidence suggests that this group of giant varanids (presumably *V. priscus*) survived in Australia until at least 50kya (Price *et al.*, 2015), and thus almost certainly encountered Australia's first people.

And although they were probably rather sluggish due to their sheer size, they could simply wait at water holes. Even a quick bite would suffice if their venom glands (now known to be shared by many living varanid species) secreted (Fry *et al.*, 2009). And then follow up their quarry with that incredible sense of smell. It is even possible that they were parthenogenic (females give birth without requiring a mate), as has been found recently in their smaller relative the Komodo dragon. These indestructible killing machines likely had a fatal flaw though. As cold-blooded animals, given their sheer mass it probably took them hours to fully warm up and be mobile. During cold weather they would have been vulnerable to attack.

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17. The Mangarahara cichlid (*Ptychochromis insolitus*)

In 2006, five new species of Madagascan cichlids (freshwater fish) were described (Stiassny & Sparks, 2006), including one thought to have been extinct for a few decades (*Ptychochromis onilahy*). Another of the five species, the Mangarahara cichlid (*Ptychochromis insolitus*), came desperately close to the same fate. Due to being quite "ugly", it was not popular in the aquarium trade (which cichlids generally are, due to their incredible colouration) and hence few people kept it. What's worse, like many cichlids it demonstrated intraspecific aggression: they occasionally killed each other. And so, it slowly declined to the point that only four known individuals existed, all in European aquariums: three males and a female. Then came news that it was probably extinct in the wild.

Realising the dire situation, possibly the last female on Earth was paired with a male, but several days later he killed her. Now only three males were known on Earth, launching a global campaign to try and find any remaining captive females that may have been missed by previous localised attempts. After literally hundreds of dead ends, Brian Zimmerman received a somewhat promising email from a Malagasy man who kept native freshwater cichlids. He didn't know of any himself, but he could take Zimmerman to a place where they might still exist.

With funding secured, Zimmerman and staff from the Toronto Zoo went in search in November 2013. Towards the end of the month-long expedition, and with hope fading fast, they reached a tiny village. A fisherman produced a small, dried fish. Most people wouldn't have given it a second look, but Brian Zimmerman knew exactly what he was looking at: a recently dead Mangarahara cichlid. He and his team were then able to record the Mangarahara cichlid at 3 of 6 potential sites near the Mangarahara River, from which the species derives its English common name (the local Malagasy name is Joba mena). But the risk of leaving them to an uncertain future in those small pools outside protected areas was too great.

In all they collected 18 or 20 individuals (accounts vary), one of which died during the 30-hour trip to the ponds of Guy Tam Hyock (who originally contacted Zimmerman). They readily bred and there are now thousands of them.

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18. Whatever floats your cephalopod (*Spirula spirula*)

If you've ever walked along the beach and come across a small, white, semi-translucent chambered spiral, you've encountered a little-known deep-sea cephalopod known as the Ram's horn squid (*Spirula spirula*). Or rather, what's left of it. The chambered shell aids in buoyancy and hence once the animal is dead it often floats on the surface until it washes up on a beach. They are so unique that they are the only species in their entire taxonomic order (Spirulida), despite their common name.

By way of comparison octopuses represent a whole taxonomic order. The diversity of extant cephalopod groups also includes the sole Vampire squid (not a squid), Bobtail squids (again, not true squids), Pygmy squids (you know the deal) and Nautiluses. While the most famous group of extinct cephalopods are the ammonites, which can be bought cheaply as fossils. Despite persistent claims that squid are from outer space, there is no DNA evidence to suggest that this is the case.

Although found by beachcombers the world over, Ram's horn squids are still rather mysterious. Living at great depths in a vast ocean, they are logistically hard to study. Although a post-mortem study of shell pathologies (abnormalities) indicates that they do not have an easy life growing up (Hoffmann *et al.*, 2018). While the historical consensus that they compose a single species is now being questioned, as they appear to form at least two distinct morphological clusters (Hoffmann *et al.*, 2021). If this is true, then it means we know even less about them.

As they are morphologically unique, their phylogenetic (evolutionary) relationships are not well understood. A recent comparative study of their Mitochondrial (mtDNA) with other cephalopods far from settles their relationships (Strugnell *et al.*, 2017). One can't help but lament the ridiculous sums spent on space research, when there are so many alien worlds under the ocean waiting to be discovered and studied.

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19. The irrepressible Robust redhorse (*Moxostoma robustum*)

Conservationists are all too aware of the vulnerability of insular (island) species to extinction compared to their continental cousins. A similar situation befalls freshwater and brackish species compared with their marine relatives. Not only is their habitat often smaller, but it is subject to introduced species, damming, pollution and riverbed modification, among other threats. Beyond the immeasurable loss of cichlids in Lake Victoria (Harrison & Stiassny, 1999), the freshwater fish (and mussels) of North America have been especially impacted (Miller *et al.*, 1989; Jelks *et al.*, 2008; Burkhead, 2012).

The Robust redhorse (*Moxostoma robustum*) was among the victims, not so much thought extinct as simply forgotten. A member of the sucker family (Catostomidae) closely related to carps and their relatives. One member of the family, the Bigmouth buffalo (*Ictiobus cyprinellus*), has recently been discovered to live for at least 112 years (Lackmann *et al.*, 2019)!

The Robust redhorse was described by Edward Drinker Cope in 1870 (Cope, 1870), with one fish he examined weighing 6lb (2.72kg). He noted that he only found the fish in the Yadkin River (North Carolina), and that local residents of the river prized it as a table fish. The species appeared sporadically in the scientific literature over the next 75 years, always based upon Cope's original description. It was also noted that no further specimens appeared to have been captured since then. This was putatively rectified with the capture of more fish by (Robins & Raney, 1956). Well, it turns out that these "new" specimens were actually from a new species, and that the real Robust redhorse was awaiting its re-recognition and rediscovery.

Two mystery fish caught in 1980 and 1985 puzzled redhorse sucker expert Dr. Robert Jenkins, who was reluctant to conclude that these large fish were a new species that had completely eluded ichthyologists for centuries (Bryant *et al.*, 1996). Then in 1991 a total of five of these mystery fish were caught, which ultimately lead to the reinstatement of the real Robust redhorse last caught by Edward Cope in or before 1870. But this meant that there was a new species in need of scientific description after all, for the specimens caught in the 1950's. The new species was named *Scartomyzon brassieus* (Brassy jumprock). But the story doesn't end there, as this new species has itself now been retracted as it is possibly a synonym of a previously described species (*M. lachneri*).

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20. The luckiest survival story ever? (*Cylindrocline lorencei*)

The current extinction crisis has resulted in the loss of innumerable species of plants, animals and fungi. But it has also provided us with a ray of hope, as conservationists have rescued some plants and animals from the absolute brink of extinction. The Chatham Island black robin (*Petroica traversi*) had been reduced to just five birds, including a single fertile female ("Old Blue"). But miraculously Don Merton and his team were able to “resurrect” the seemingly doomed species (Butler & Merton, 1992). While plants can theoretically be restored from a single individual, such as *Kokia cookei* which was saved after a branch was grafted onto the related *K. kauaiensis*. Or the single male Wood's cycad (*Encephalartos woodii*) which has subsequently given rise to many clones (see No. 15). But one story of botanical rescue stands peerlessly above all others: that of *Cylindrocline lorencei*.

Part of the reason that we know that the historical extinction rate must be much greater than that which is known is because many species and subspecies are only known from one or a few individuals collected serendipitously. On the island of Mauritius east of Africa, a single plant of a new species in the daisy family (Asteraceae) was found (Scott, 1987). Despite extensive surveys no other individuals have ever been found, and it is likely that this really was the very last individual of its species. A truly miraculous find in its own right.

Luckily seed was able to be gathered (the second miracle) because the only known specimen died in 1990. Conservationists would still have a chance to save the species, like the Judaean date palm. However, horror set in as germination tests indicated that the seed was not viable. Insert miracle three, when staining tests showed tiny clusters of live cells in some of the seeds. Insert miracle four, as a new breakthrough meant that it might be possible to grow part of a seed embryo in vitro. The fifth and final miracle was three tiny clones, with re-introduction attempts now underway (Hind *et al.*, 2009). If ever the actions of a species told us that it wanted to avoid extinction it was *Cylindrocline lorencei*.

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21. Was its rediscovery a false hope? (*Rhinoceros sondaicus annamiticus*)

There are currently five living species of Rhinoceros in four genera (family Rhinocerotidae), though perhaps as many as ten others have become extinct since the start of the Late Pleistocene (<126ka). While almost a dozen subspecies of the five living species are thought to be extinct or extinct in the wild. This helps to highlight just how much biodiversity we have truly lost.

One subspecies, the Vietnamese Javan rhino (*Rhinoceros sondaicus annamiticus*), was feared to be extinct until it was rediscovered in November 1988 when a female was shot. Subsequent surveys estimated that no more than 10-15 animals survived (Schaller *et al.*, 1990). In light of the subsequent decline and extinction of this population (and thus probably the subspecies), with the last known individual killed by a poacher on 29 April 2010 (Brook *et al.*, 2011), it raises the question as to what the subspecies' "rediscovery" actually amounted to.

It is possible that the rediscovered population (10–15 animals) was too small to be viable (or there were not enough reproductively viable individuals, etc.), and thus resulted in a kind of false hope that the subspecies could be rescued. And thus, it is perhaps time to reserve the term "rediscovery" for (sub)species that are shown to be viable. This of course raises many questions about the notion of what constitutes viability: the capacity for a population (subspecies, species etc.) to exist indefinitely into the future.

Nothing lasts forever, everything eventually becomes extinct, but the existence or absence of an extinction timeframe is critical. One thousand members of a species are no better than none if they cannot perpetuate their kind into the future: life doesn't always go on. The problem is in determining when this threshold of guaranteed extinction has sadly been passed.

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22. The importance of demography (*Strigops habroptila*)

Humans have been deliberately or accidentally moving animals outside their natural range for thousands of years. The retrospective analysis of how many macaws went extinct in the Caribbean is extremely difficult because of prehistoric translocations (Wiliams & Steadman, 2001; Wiley & Kirwan, 2013). One of the first translocations for conservation purposes was that undertaken by Richard Henry (1845–1929) on behalf of the New Zealand Government in the 1890's.

He relocated hundreds of New Zealand's flightless birds (Kakapo, Kiwi and weka) to Resolution Island, but the invasive stoat (*Mustela erminea*) swam to the island and devastated the helpless birds. Henry's efforts and his writings were profound (Henry, 1903), later inspiring and informing Don Merton who would himself later rescue (with help) the Chatham Island black robin (*Petroica traversi*). Merton repaid the favour by raising Henry from obscurity (Taylor, 2007), who had died in 1929 with the local Helensville postmaster the only attendant at his funeral.

The global Kakapo population seemingly did not fare any better than Henry. By the early 1970's the species, a giant flightless parrot, was feared extinct. A false reprieve for the species occurred when a total of 18 animals were found later that decade, all of which were male. A genetically diverse population of fertile individuals existed, yet without any (fertile) females the species was only to actualise its inevitable extinction. For extinct it would inexorably become until a search of Stewart Island uncovered a population of around 170 individuals. Unfortunately, feral cats were also present on Stewart Island, and the Kakapo slowly declined to around 50 birds in the mid-1990's.

Since 1995, the Kakapo Recovery programme has been in place, with the total global population (adults and juveniles) pushing past 200 on 17 August 2019 for the first time in more than half a century. But the species' recovery suffered a further setback around the time of the landmark, as aspergillosis (a fungal disease that affects avian species around the world) was found in Kakapo's for the first time. A number of young birds have died, while dozens of others have been successfully treated. Intensive ongoing monitoring is ensuring that the population curve of the flightless parrots continues to go upwards.

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23. A parrot in the outback, but desert still exist? (*Pezoporus occidentalis*)

The Night or Spinifex parrot (*Pezoporus occidentalis*), like the Kakapo, is ground-dwelling. In Australia's interior ("outback") it was reported as locally common in the mid-1800's. But the last confirmed record was in 1912, and with the spread of red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) the species' survival looked grim. But it was never officially declared extinct, and sporadic reports of the species would filter in (e.g. Storr, 1960; Ives, 1971). The only two species that it could have been confused with, the other two members of the genus *Pezoporus* (*P. flaviventris* and *P. wallicus*), were only found close to the southern and eastern coasts of the country.

In 1979, ornithologist Shane Parker had perhaps the most credible post-1912 sighting to date (Blyth, 1996). Then in 1990 a dead individual was found near Boulia in Queensland, suggesting the species' continued existence (Boles *et al.*, 1994). An officially accepted sighting by biologists Robert Davis and Brenden Metcalf took place near Minga Well in Western Australia's Pilbara region in 2005 (Davis & Metcalf, 2008). A second dead specimen was found in 2006 in the Diamantina National Park in Queensland (Cupitt & Cupitt, 2008; McDougall *et al.*, 2009).

Given the fact that the species was never declared extinct, it was found in remote areas not often searched, and there were sporadic reports of its survival, it begs the question of whether the species was ever really rediscovered. Museum collections have many specimens that belong to species which scientists do not know for certain still exist. It is not that they are thought to be extinct, but simply that scientists do not have infinite resources to constantly monitor the population status of every single (sub)species on Earth.

The relevant difference is in whether there are any known or probable threats facing the population/s. With the spread of introduced mesopredators (foxes and cats) in Australia, predation upon a ground-dwelling psittacine is unfortunately almost an assured thing. But even if the threat posed was enough to suspect the Night parrot of being extinct, which sighting or specimen was the one which rediscovered the species?

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24. An unenlightened end (*Bactrurus cellulanus*)

Universities are by all accounts intended to be places of education, where some of the most enlightened people in the world ply their knowledge. Yet the unfinished Jordan Hall at Indiana University's Bloomington campus was being built upon a spring- or seep-fed stream. Four species of crustaceans lived in the water, including a new species of amphipod (*Bactrurus cellulanus*). Four specimens were collected in December 1962 and January 1963, but it wasn't found in June 1965 for unknown reasons. It was officially described as a new species in 2001 (Koenemann & Holsinger, 2001), by which time the stream had long since been diverted and the locality destroyed during remaining construction of the hall building. The species has never been recorded elsewhere and it is today considered to be extinct (Taylor & Niemiller, 2016).

Of all of the taxonomic groups of animals that have had a significant number of recent extinctions, crustaceans are arguably the most neglected (López *et al.*, 2021). Part of the explanation probably lies in the fact that they are often very small and inhabit aquatic environments, as well as their underappreciated diversity, including: amphipods, barnacles, brine shrimp, clam shrimp, copepods, crabs, crayfish, fairy shrimp, isopods, krill, lobsters, ostracods, prawns, sandhoppers, scuds, seed shrimp, shield shrimp, tadpole shrimp, water fleas and woodlice.

Many of them constitute stygofauna, eking out a subterranean existence, where they filter the water they live in. Such low-energy environments force stygofauna to usurp the demography of much larger animals, living long lives and reproducing very slowly (many are very rare and very localised). So next time you pass a small stream or pool, consider that it might contain a myriad of miniscule crustaceans or other invertebrates, and hence think about how your activities may affect its water quality.

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25. Anthropogenic extinction sucks (*Xerobdella lecomtei*)

The European land leech (*Xerobdella lecomtei*), a terrifying prospect for many people, is sadly one of the earliest victims of climate change. It was endemic to cold-adapted areas of Austria, where it lived in the moist soil. The last known population occurred in birch forests near Graz, but an annual average summer temperature increase of 3°c over the period 1961–2004 is thought to have killed off the species (Kutschera *et al.*, 2007).

Between 2001–2005 only a single leech could be found, which was taken into captivity and studied as there had only been a single study of its biology in more than 130 years (Reisinger, 1951). The individual subsequently died and its DNA was compared with other species which showed that in fact it belonged to the taxonomic family Xerobdellidae and not Haemadipsidae as historically thought. Only in (probable) extinction was the species' relationship to other leeches known.

The New World has its own enigmatic leech, the New England medicinal leech (*Macrobdella sestertia*). It has been rediscovered several times since its description in 1886 (Carlson & Phillips, 2020), including a major range extension to South Carolina in 2008 (Poly, 2018). Yet the latter is the last record of the species, and it may now be extinct (Carlson & Phillips, 2020). However, given the very large range of the species, and relatively few people who could identify it, there is every chance that it still survives.

Yet the worry that it may have already disappeared is incidentally a positive one, as it raises awareness about the species and thus hopefully persuades people to learn how to distinguish it from other leech species. Despite their superficial resemblances, the more than 600 known leech species around the world are each unique and merit conservation equally.

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26. "An apple a day keeps...extinction away" (*Malus* sp.)

Today's selection of fruit at a chain supermarket may seem appealing, and to some degree it is. Yet for any fruit variety you might pick up and examine, there exists a variety that is far superior in taste. Yet you won't find these varieties in supermarkets because they can't be commercially grown in the quantities required. Instead, it is up to home gardeners to perpetuate these varieties (often heirlooms) into the future, as demand for them is what is keeping them from slipping into oblivion. Well not quite.

The North American cider making industry resulted in a proliferation of cider apple varieties, with perhaps as many as 15,000 at its peak. And though the industry is a shadow of its former self, apple trees live for a very long time. With old nursery catalogues, watercolour paintings and wax models in hand, apple seekers visit America's abandoned orchards looking for lost apples. And they have been remarkably successful.

Dozens if not hundreds of apples have been rediscovered, although the true number is difficult to calculate. After all there is no centralised list of missing apples, though apple hunter Tom Brown is said to have rediscovered 1,000 lost cultivars alone. Unsurprisingly, some "lost" varieties are more hallowed than others.

The Holy Grail of lost apples being the Taliaferro (pronounce Toliver) that Thomas Jefferson wrote so highly of. Part of the difficulty in searching for it was the lack of an accurate pomological description, but Susan Walker (Chief Magistrate Judge) has uncovered one (Hatch, 2018). It means we are one step closer to rediscovering the Taliaferro apple like that other famous target, the Junaluska apple named after Cherokee Chief Junaluska. The more apple varieties we retain, indeed the more fruit and vegetable varieties of all kinds that we grow, the less that disease and climate change threaten our food security.

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27. Miniature giants on Mediterranean islands (*Mammuthus creticus*)

There are three living species of Proboscideans (elephants and their relatives), two in Africa (*Loxodonta africana* and *L. cyclotis*) and one in Asia (*Elephas maximus*). Yet this diversity is paltry compared to the Late Pleistocene Proboscidean landscape, when four groups (Elephants and mammoths, gomphotheres, mastodons & stegodonts) had surviving members. The greatest concentration of these were elephants and mammoths which inhabited many of the Mediterranean's islands.

On the island of Crete alone lived possibly three elephantids: *Mammuthus creticus*, *Elephas creutzburgi* and perhaps *Elephas chaniensis*, although the latter may have become extinct earlier. The island's extinct Late Pleistocene–Holocene fauna also included several deer (*Candiacervus* sp.), an otter (*Lutrogale cretensis*), a giant golden eagle (*Aquila chrysaetos simurgh*), an owl (*Athene cretensis*), a tortoise (*Testudo marginata cretensis*) and a large mouse (*Mus minotaurus*).

Mammuthus creticus was christened as *Elephas creticus* by the great Welsh palaeontologist Dorothea Bate (Bate, 1907), misidentifying it as an elephant instead of a mammoth. Though whether she actually made a mistake over a century ago is hard to say since she was working with a far smaller body of knowledge than us today. Remarkably, an 800,000-year-old section (43bp) of mitochondrial DNA (mtDNA) from an *E. creticus* individual was found which started a debate about the generic placement of *E. creticus* (Poulakakis *et al.*, 2006; Orlando *et al.*, 2007).

This debate was resolved through a study which looked at existing fossil specimens as well as newly uncovered ones, showing that *E. creticus* was in fact the smallest mammoth known to have ever existed (Herridge & Lister, 2012). It is believed to have died out prior to the Holocene (>11.7kya). By contrast, the latest surviving mammoth population inhabited Wrangel Island and may have died out only 3,700 years ago (Vartanyan *et al.*, 2008).

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28. Jamaican a monkey out of *Xenothrix mcgregori*

Like other mammalian groups primates have suffered a significant number of recent extinctions. Including the largest ape known to have ever existed (*Gigantopithecus blacki*), and a dozen or more large to gorilla-sized lemurs in Madagascar. While in the Greater Antilles an entire tribe of monkeys (Xenotrichini) became extinct. On Hispaniola, the Hispaniolan monkey (*Antillothrix bernensis*) and the La Hotte monkey (*Insulacebus toussaintiana*) were known. While on Cuba the semi-terrestrial Galeran monkey (*Paralouatta varonai*) existed before it died out.

Only one other recent Caribbean primate is known, and is arguably the most mysterious of all. It was previously considered part of the Xenotrichini, but DNA analysis has found that it shares a more recent split from a species outside of the Xenotrichini tribe (Woods *et al.*, 2018). This suggests that monkeys colonised the Caribbean at least twice, presumably via rafting on floating vegetation dislodged during bad weather.

The Jamaican monkey (*Xenothrix mcgregori*) is the most recently known Caribbean primate, with a radiocarbon date of 473BCE with an error margin of 34 years (Cooke *et al.*, 2017). It appears to have had rather large eyes indicating nocturnal behaviour, and to have been relatively slow moving based up its femur. The latter is not particularly surprising as oceanic islands (*i.e.* islands never connected to a mainland) tend to be devoid of predatory species as basically all but birds of prey can fly there. And larger animals such as a carnivore large enough to predate the Jamaican monkey tend to need larger founding populations.

Unfortunately, because there are so few remains of Caribbean primates it is unclear when they went extinct, although *Xenothrix* is a good candidate as the last survivor. Indeed, there is an historical mention (Sloane, 1725) of a primate-like mammal from Jamaica, and which could therefore conceivably refer to the Jamaican monkey. Although as with early historical reports of animals, caution must be eased as these may refer to introduced species or even be of uncertain geographical origin (*cf.* MacPhee & Fleagle, 1991).

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29. Do you dig this venomous mammal? (*Atopogale cubana*)

Many plants and animals have many close relatives, while some only have a few, and a handful are truly unique. And then there are those groups with multiple species that made it until the Late Pleistocene–Holocene but are now all extinct.

The family Nesophontidae (West Indian shrews) until recently consisted of ten species distributed throughout the Greater Antilles, including Cuba, Hispaniola, Puerto Rico and the Cayman Islands. Radiocarbon dating suggests that most of them survived until European settlement, indicating that the introduction of rats and deforestation likely caused their extinction. Although any retrospective analysis of extinction causes inherently contains at least some uncertainty. Another family in the order Eulipotyphla also deserves a discussion.

One of the most unusual mammalian families alive today is Solenodontidae, prehistoric looking burrowing animals that are venomous. There are two living species, both of which have been rediscovered, while two other extinct species survived until the last 100,000 years. The Cuban solenodon (*Atopogale cubana*) is nocturnal in addition to spending much of its life underground during the day, which helps explain the paucity of records. It was rediscovered in 1975 in the eastern part of Cuba from where all known recent records come, although fossils have been found all over Cuba.

They scour the forest floor at night in search of invertebrates and small vertebrates to eat, possibly using echolocation to do so. With so little known about the species every record is news worthy and adds to our meagre knowledge of the species. The species' stronghold is in the Alejandro de Humboldt National Park, from where the most recent records have come in 2012 and 2013. The Hispaniolan solenodon (*Solenodon paradoxus*) is faring much better, and indeed has recently been discovered to represent three distinct subspecies.

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30. The Duke is missing! (*Megadytes ducalis*)

Rediscovering a species is the hope of any biologist, not just for personal glory but to know that it still survives. This task is made much easier by having access to museum specimens that have accurate locality data, and thus knowing where to look. While morphological, biological and ecological data can inform a searcher what to look for, how to look for it, and when. Unfortunately, such data is often written on a label attached or pinned to a specimen and can become lost, stolen, misplaced or destroyed. Labels can even be accidentally or deliberately swapped, leading to erroneous suggestions that a species occurred or occurs more widely than currently recognised (Burbidge, 2017).

Another equally difficult situation arises when trying to find an extant population when the locality data is either wrong or only very general. For example, the freshwater crab *Austrothelphusa insularis* is probably still extant, but it is not clear where the single known specimen came from (Esser & Cumberlidge, 2008). Incredibly, a number of species have been rediscovered with only such poor locality data to work with, albeit with more luck or by coincidence rather than outright skill (Herbert, 1993; Maynard et al., 2019; D'ávila *et al.*, 2020; Wagh & Hurrah, 2020).

The world's largest diving beetle, *Megadytes ducalis*, known colloquially as 'the Duke', threatened to remain lost forever as the locality data with the original specimen was very vague ("Brazil"). Indeed, with only a single male specimen known, the species was listed as extinct by the IUCN (WCMC, 1996).

Recently, a search of museum specimens found 10 additional specimens with precise locality data, including the first known female with a total length of 47.4mm (Hendrich et al., 2019). All of the new specimens had a label that suggested Santo Antônio da Barra of the location, which is today known as the Condeúba municipality in the southern part of Bahia state. The habitat here is part of the Cerrado or tropical savanna that covers around 2 million km^2 with distinct wet and dry seasons. The best method for catching the species appears to be a trap made using a large container with a funnel baited with meat. Nobody knows for sure whether the species still exists, as the Cerrado biome is under threat from agriculture and the species appears genuinely rare, but the imperative to look for it pushes aside any doubts.

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31. Eradicating the threat of extinction (*Abutilon julianae*)

Islands have played a major role in conservation programs to save endangered species in Australia, either by moving species to islands where there are no predators or competitors, or by eradicating feral animals from them. While the continent's recent mammal extinction rate is the worst in the last 500 years, it would have been even worse if not for such translocations/havens.

Species such as the Greater stick-nest rat (*Leporillus conditor*), Gould's mouse (*Pseudomys gouldii*) and the Shark Bay bandicoot (*Perameles bougainville*) have all been saved from extinction in this way. While many predator-proof fenced areas have been established on the mainland to maintain semi-wild/*ex situ* populations such as the Greater bilby (*Macrotis lagotis*), Tanami rufous hare-wallaby (*Lagorchestes hirsutus* ssp. nov.) and the Woylie (*Bettongia penicillata ogilbyi*).

The eradication of ruminants such as goats and cattle as well as other herbivorous species from many islands has also allowed many native insular floras to rebound. On Phillip Island in the south-Pacific, two plant species were thought to be extinct: the Phillip Island glory pea (*Streblorrhiza speciosa*) and the Norfolk Island abutilon (*Abutilon julianae*). The former was collected during the mid-1800's and briefly grown in England after it became extinct on the island, with its taxonomic placement only recently resolved (Heenan *et al.*, 2018). The latter was also known from the larger Norfolk Island to the north but was last recorded there in 1912 and has not been seen since.

Following a rabbit eradication program in the early-to-mid 1980's, the Norfolk Island abutilon was rediscovered in 1985, perhaps growing on inaccessible cliffs away from hungry herbivores until they could spread to more accessible areas where the species was rediscovered (Coyne, 2011). Another bonus was Margaret McCoy's discovery of a single *Achyranthes* shrub that was initially assigned to the Norfolk Island species, but was subsequently described as a new species (de Lange & Murray, 2001)

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32. Howe did the ninja turtle's cousin become extinct? (*Meiolania platyceps*)

Lord Howe Island lies 600km east of the Australian mainland, and as far as anyone knows it was first visited in 1835 by Europeans. Since that time the island has undergone massive biodiversity changes, with introduced species and habitat destruction rendering many species and subspecies extinct. The most enigmatic of these is the Lord Howe long-eared bat (*Nyctophilus howensis*) known only from a single incomplete skull found in 1972 of recent origin (McKean, 1975). Only one species is known to be extant on the island, although (Etheridge, 1889) noted that "a larger species was occasionally seen", which may refer to this species.

Thankfully some species have been rediscovered, including *Davidrentzia valida* (Rentz's Strong Stick-insect) and the world-famous Lord Howe Island stick insect (*Dryococelus australis*). However, one species seemingly disappeared long before humans ever arrived on the island, and so the cause of its extinction remains somewhat uncertain.

The extinct family Meiolaniidae (turtles with armoured heads and tails) was represented by several species at the start of the Late Pleistocene. Distributed in Australia and the Pacific Islands they slowly died out with the latest survivors possibly making it into the middle to late Holocene (<5ka) (White *et al.*, 2010). On Lord Howe Island fossils of *Meiolania platyceps* were initially found in matrix at two beaches, leading to the suggestion by A. R. McCulloch that the species was marine and only came ashore to lay eggs (Anderson, 1925).

Further remains have since been found which demonstrate that it was a terrestrial species with very restricted mobility (Anderson, 1930), perhaps due to a lack of predators that would otherwise have forced the species to retain greater ability to move. Its significant armour likewise suggests that it either evolved from an ancestor that required serious defence mechanisms or was used to fight each other.

The species unfortunately appears to have been doomed by rising sea levels during the end of the Pleistocene, which greatly reduced the size of Lord Howe Island to the point that there was no longer sufficient habitat, especially as the island is topographically complex. A fate similarly shared by the enormous 50–200kg rodent *Amblyrhiza inundata* (Anguilla giant hutia) (McFarlane *et al.*, 1998).

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33. Citizens can contribute to conservation too (*Dendrolagus mayri*)

Conservation biology is an open field that greatly benefits from the observations of interested citizens who do not possess a relevant degree, known as "citizen science". Today there are a number of websites where citizen scientists can upload their photographic observations of flora, fauna and fungi, and thus contribute vital data about the distribution, seasonality, habitat etc. of species. As it can be difficult to identify many species from their close relatives, experts often provide definitive or probable identifications, when the quality of a photo is good enough to show diagnostic characters.

Experts also scour these citizen science records, such as iNaturalist and bugguide.net, looking for possible new and missing/extinct species. In a few cases these records have been flagged as possible IDs by the knowledgeable citizens who took the photos but await expert confirmation. In this manner several taxa have been rediscovered (Grinter & Van Den Broeke, 2013; Douglas & Mathison, 2018; Richart *et al.*, 2019), the latest being the Dumbéa River pipefish (*Microphis cruentus*).

In reality, many of the world's great discoveries/inventions have been made by self-taught people. British amateur botanist Michael Smith, who graduated university with a biology degree but is employed in unrelated work, looks for rare plants in his spare time. Upon hearing of the Wondiwoi tree-kangaroo (*Dendrolagus mayri*) from New Guinea, known only from a single specimen collected by eminent evolutionary biologist Ernst Mayr in 1928, he organised an expedition to look for it.

Armed with local knowledge, and after finding signs of tree-kangaroos in a remote area, the team succeeded in photographing what experts say appears to be the long-lost tree-kangaroo (Pickrell, 2018), although absolute confirmation will require a specimen or at least DNA. Less well known than their terrestrial kin, especially the Red kangaroo (*Osphranter rufus*) of the Australian outback (though it actually occurs more widely), the evidence suggests that macropods (kangaroos, wallabies, pademelons etc.) actually evolved from arboreal ancestors. They are members of the order Diprotodontia ("two forward teeth"), which also includes possums, wombats, the koala, cuscuses and gliders.

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34. A most mysterious missing mammal (*Biswamoyopterus biswasi*)

There is no doubt that mammals, particularly large predators, receive a disproportionate amount of conservation attention. Yet ironically, many mammals are little known. Apart from some species being genuinely elusive, a lot of this has to do with either taxonomic confusion or the difficulty of identification in the field.

For example, the King genet (*Genetta poensis*) is listed as having not been recorded since 1946 by the IUCN (Gaubert & Do Linh San, 2015), yet the species has been listed as extant elsewhere (Nigeria) under a different common name ("Forest genet") (Okiwelu et al., 2008). While many of the recently recognised extant mammal species derive from splitting a single species into multiple species or re-instating species that were later lumped together (e.g. McGregor *et al.*, 2020; Jackson *et al.*, 2021).

One mammalian genus illustrates this better than any other: *Biswamoyopterus*. The Nadampha flying squirrel (*Biswamoyopterus biswasi*) was only known from a single specimen collected in north-eastern India. What is truly remarkable is that the first and only known specimen was collected only in 1981 despite the animal having a 405mm long body and a 605mm long tail (Saha, 1981), meaning the animal's total length was just over 1 metre! No further specimens of the genus were found until a second species, the Laotian giant flying squirrel (*B. laoensis*), was described from Laos based upon an almost identically sized individual (Sanamxay *et al.*, 2013). A third species was then described based upon two museum specimens (Li *et al.*, 2019).

However, two further specimens of the genus from northern Laos and Myanmar have characteristics intermediate between all three species, suggesting that the genus may be monotypic (*i.e.* consist of only a single species) (Li *et al.*, 2020). In a time of high extinction rates, describing species that are only known from a handful of specimens at most can help to bring attention to their plight. But there is the danger that such small sample sizes will lead to the false treatment of intraspecific (that is, within species) variation as being good diagnostic characters that separate species.

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35. Wētās aren't naughty, but they're a handful (*Motuweta isolata*)

By vertebrate standards insects are rather small, although given that there are millions of species there is considerable size variation, and some are quite large. Stick insects come to mind, though most insect orders have oversized members (https://en.wikipedia.org/wiki/List_of_largest_insects). Naturally, there are claims of larger unverified specimens of these species, which is not to say that they cannot be true.

One fascinating group of large to very large insects are the wētās of New Zealand, a tribe of giant crickets, with about 70 known species and probably some undescribed ones too. Given their large size they are unfortunately targeted by introduced predators such as cats, rats and weasels, with three species in the genus *Deinacrida* having to be rediscovered (*D. elegans*, *D. parva* and *D. tibiospina*). While the Canterbury Museum has in its collection an unidentified juvenile specimen collected more than 100 years ago, which may belong to an undescribed (and possibly extinct) species (https://www.canterburymuseum.com/discover/blog-posts/the-mysterious-canterbury-giant-weta/).

The Mercury Islands tusked wētā (*Motuweta isolata*), with its enormous tusks used by males to fight each other, looks like a demonic cricket from hell (in an endearing way). Nocturnal like most other wētās, it was endemic to Middle Island where it was discovered in 1970 (Johns, 1997), but gradually declined in the presence of numerous native predators.

A captive breeding program was instituted in 1998, consisting of a single male and two females, just in time as the species has not been recorded on Middle Island again for almost two decades. It bred successfully in captivity and has since been reintroduced to the wild elsewhere within the Mercury Islands. However, as with the Black robin (*Petroica traversi*), the tiny founder population means that genetic diversity is very low, meaning that ongoing conservation monitoring is essential.

The future indeed looks bright for the species, but complacency must never be allowed to flourish within conservation biology. A second species in the genus, the Raukumara tusked wētā (*Motuweta riparia*), was described in 2002. In the face of danger, it has the extraordinary habit of jumping into the nearest stream and remaining underwater until its foe has left (Gibbs, 2002). As many species of plants and animals are only known from museum specimens with little to no observational data, many similarly quirky behaviours have probably been lost.

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36. See the Jellyfish tree by the sea (*Medusagyne oppositifolia*)

Plants and animals are fundamentally different, so it is occasionally necessary to remind oneself that they share a common ancestor. Although certain algae-eating animals can borrow chloroplasts to indirectly photosynthesise (*kleptoplasty*). In seed-bearing plants germination often requires specific conditions which can make them extinction prone if recruitment rates are very low or habitat changes between generations are radical.

The rediscovered Indian tree species *Madhuca insignis* drops most of its seeds into the rivers that it grows next to, which makes it difficult for germinating seeds to get a root hold in the constantly flowing water. Yet saving and storing the seeds for future germination is not possible as they lose their viability after only a few weeks. The less-than-optimal solution is to collect and germinate seeds ex situ and replant them into the wild after many months to ensure that they are healthy and likely to survive (Joshi *et al.*, 2019).

On the island of Mahé in the granitic Seychelles, the Jellyfish tree (*Medusagyne oppositifolia*) was rediscovered in the 1970's. It gets its common name from the upside-down jellyfish-like fruits once they have opened up. Yet the species was far from saved at this point, as there has been no wild germination of seeds since its rediscovery.

Thankfully, many seeds have been germinated under *ex situ* conditions when humidity is high, an environmental factor lacking among the sparse wild stands. So, either the vegetation has been thinned to the point that the air does not retain much moisture, or its natural habitat on the island lay elsewhere and what is left are the remnants of less than ideally situated plants at the edge of their past distribution. Yet this too did not ensure the species' survival, as novel methods in micropropagation have needed to be created to rejuvenate long-term *in vitro* cultured plants due to limited genetic diversity, slow growth rate and cessation of growth in young plants (Marriott & Sarasan, 2010).

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36. An extinct dog on Sardinia, canid be true? (*Cynotherium sardous*)

The speed of evolutionary change, especially speciation (the origin of new species), is a constantly (and hotly) debated topic. But there is no doubt that evolution can occur geologically rapidly under certain circumstances, especially if selective pressures are maintained in a single direction for long periods. For example, if selection towards larger body size is maintained for many generations, with larger individuals equally as prone to the selective pressure, then larger and larger body sizes will evolve *ceterus paribus* (*cf.* all other things being equal).

But evolutionary change can also come about from the opposite manner, namely, the cessation of pressures to maintain characteristics. The most obvious example of this are animals that transition to perpetually live inside caves, with the pitch-black atmosphere rendering energetically costly eyes and pigmented skin essentially useless. As a result, they soon (evolutionarily speaking) lose their eyesight and become pale, along with evolving a slower metabolism.

Rapid evolutionary change can also obfuscate evolutionary relationships, as the Sardinian dhole (*Cynotherium sardous*) illustrates. The species once inhabited modern day Corsica (France) and Sardinia (Italy), as they formerly formed a single island, but it became extinct around the time of the Late Pleistocene–Holocene transition (c.11.7ka). Despite having been described in 1857 (Studiati, 1857) its evolutionary relationships have been much debated, with a number of species proposed as its ancestor, including *Xenocyon lycaonoides*, *Lycaon* sp. and *Cuon* sp. (Lyras & Van der Geer, 2006; Ciucani *et al.*, 2021). As Lyras & van der Geer (2006) succinctly put it:

"Inherited ancestral characters and acquired adaptations to different ecological pressures could not be separated".

Morphological comparisons have been rendered moot now with the sequencing of the species' genome, which shows divergence from *Cuon* around 885ka and complete genetic separation by 300–500ka (Ciucani *et al.*, 2019).

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37. The man who cried shark? (*Carcharhinus hemiodon*)

Sharks and their relatives (Chondrichthyes) are increasingly seen as important components of marine, brackish and freshwater ecosystems thanks to the work of conservationists and nature documentaries. Unfortunately, they are also the target of shark fin hunters, recreational fishers, nets and a host of other threats. Surprisingly many species are known from relatively few specimens, especially members of the genus *Glyphis*.

Despite their large size (relative to other groups of animals), it can be difficult to identify and study aquatic animals, particularly when they look similar from above the water provided that it is not murky. Consequently, a number of species have been rediscovered: *Carcharhinus borneensis*, *C. leiodon*, *Glyphis gangeticus* and *Rhynchobatus cooki*. While several remain missing and are possibly extinct: *Carcharhinus obsolerus*, *Torpedo suessii*, *Urolophus armatus* and *U. javanicus*.

The first criterion for a target species when looking for species thought to be extinct should be that it is actually missing, and hasn't already been rediscovered. The Pondicherry shark (*Carcharhinus hemiodon*) was last recorded in the mid-to-late 1980's, and then rediscovered in 2007 (Rodrigo, 2016; Sankar, 2018). With several sightings and photographs of the species since then, including one photo that has subsequently been shown to be a bull shark, reminding us that species identification is a critical skill to possess for conservation purposes if nothing else.

Yet the pseudo-conservationist Forrest Galante spun a narrative during the first Shark Week special of his program 'Extinct or Alive' (2019) which made out as if his wife, Jessica Evans, was responsible for the species' rediscovery (nepotism). This is only one of a number of instances of bending the truth, or simply ignoring it, by Galante (e.g. Wight, 2020). To date, though he claims to have rediscovered around eight species, he has not published a single peer-reviewed paper on any of these alleged rediscoveries.

Instead, he constructs a fake rediscovery narrative and then simply moves on to the next target without so much as trying to do anything to protect the species he has allegedly rediscovered. Instead, he seemingly simply leaves them to the fate we are meant to believe that they were thought to have befallen in the first place. Those are not the actions of a man who actually cares about these species, but of an egotistical man who is greatly interested in maximising his public image.

The generosity of the public in donating to conservation and environmental causes is not something to be taken for granted at the best of times. Charlatans like Galante do more harm than good when the public think that professional conservationists are incompetent at rediscovering species, while Galante with TV crew in tow manages to track down their quarry in a mere matter of days. In reality, and as this book hopefully shows, the rediscovery of a species (or subspecies) is only the first step in a long process to recovery if the population is viable. Cutting it off there and simply moving on is worse than not attempting rediscovery since it is a wasted effort that

teases the survival of a species then relinquishes it to its fate without so much as a care.

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38. Deader than the dodo? Spotted but not seen (*Caloenas maculata*)

The dodo (*Raphus cucullatus*) is an icon of extinction that might not have been if it weren't for Lewis Carroll's depiction of the species in his stories according to one suggestion (Fuller, 2002). While from a scientific standpoint, there is a recent debate over how fat or slim the dodo actually was (Angst *et al.*, 2011a, b; Randall *et al.*, 2014; van Heteren *et al.*, 2017). So, there is some morphological ambiguity to the discovery that the dodo is essentially an oversized terrestrial pigeon, as genetic analysis supports its long-held placement in the order Columbiformes (Heupink *et al.*, 2014).

Yet despite its iconic status, and having disappeared nearly 400 years ago, some artistic depictions of the species have only recently been published (Teixeira, 2019). While its extinction date has been vigorously debated in the last couple of decades. But at least we know where the species lived, on the island of Mauritius in the Mascarene Islands north-east of Madagascar

The mysterious Spotted green pigeon or Liverpool pigeon (*Caloenas maculata*) is only known from two specimens collected between 1783 and 1823 from an unknown locality. However, the principal localities visited by its collectors and the species' short wings suggest it inhabited a Pacific Island (BirdLife International, 2016). It has been suggested that the species inhabited Tahiti based upon an alleged sighting of a bird, the "tītī", fitting the description in 1928 (Raust, 2020). However, ornithological activity in the region has historically been sufficient to make this very unlikely, with no known author having recorded the species since 1823.

The species' true home may therefore be lost forever, making the species deader than its relative the dodo in a sense. The Tahitian origin hypothesis remains the pre-eminent candidate thanks to new research into an old mystery (Raust, 2020).

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39. When rarity is temporary (*Castiarina insculpta*)

The Miena jewel beetle (*Castiarina insculpta*) was originally described from a single female specimen (the "holotype") collected in 1920 by Critchley Parker in the Great Lakes region of Tasmania (Carter, 1934). A second dead female specimen was collected in 1965, but several surveys since the 1980's had failed to locate any more and it was believed to be extinct (Bryant & Jackson, 1999).

It was finally rediscovered in February 2004 when two dead female specimens were collected within several days (Smith et al., 2004). Another dead female specimen was apparently found in 2008, and in 2010 a dead female was found at the bottom of a boat while trout fishing (Tabor & Bowden, 2010). A field trip by the Tasmanian Field Naturalists Club on 29 January 2012 failed to locate any specimens but did find a male and female of the equally rare *Castiarina rudis* (Bonham, 2012).

During the summer of 2012-13 over 100 hundred live individuals consisting of both sexes (the first known males) were found at several localities and included range extensions (Bonham et al., 2013). The host plant was thus established as *Ozothamnus hookeri* (Scaly everlasting), whose expansion has been credited as the reason for the species' sudden abundance (Spencer & Richards, 2014).

With firm knowledge of the species' host plant, it was now possible to undertake summertime searches for the species when the host was in flower from mid-January to early March. However, in 2014 relatively few individuals were found compared with the previous year, leading to the suggestion that the larval stage of the beetle was at least two or three years in duration (Spencer & Richards, 2014).

Elevated records of the species in 2015 followed by much reduced numbers in 2016 lended support to a two-year cycle (Richards & Spencer, 2016). 2016 also resulted in a second known food plant, *Baeckea gunniana* (alpine heathmyrtle), for the species (Ibid.). A second record of a Miena jewel beetle feeding on a *B. gunniana* flower was recorded (Richards & Spencer, 2017).

But then came the Great Pine Tier fire of 2019 and destroyed an estimated 50% of the species' habitat (Richards & Spencer, 2020). Importantly, range extensions were being noted outside the fire zone, and the species is not likely to go extinct any time soon. But it will take an estimated 10 years for the host plant *O. hookeri* to regrow to a suitable size to enable the larvae to bore safely, thus this beautiful species is now on the long road to recovery.

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40. A glowing report: rediscovery of a bioluminescent mushroom (*Neonothopanus gardneri*)

If plants are little mentioned as part of the current biodiversity crisis, then fungi are completely forgotten, despite their important functional roles as decomposers in many ecosystems. The true extent of recent fungi extinctions is unknown, partly because there have historically been relatively few mycologists, while many species are small and cryptic soil inhabitants.

However, one extinction hotspot is known, the islands of Chichijima and Hahajima (part of the Ogasawara Islands), from where 23 of Japan's 26 declared extinct mushroom species were found (Hosaka *et al.*, 2018). Most were found only once during the 1930's and 1940's at a single location, and were never seen again. Introduced species and habitat destruction are most likely to blame, as these have caused many extinctions on the Ogasawara Islands since the 1800's. This is an enormous loss as the islands were Asia's version of the Galápagos Islands, which future visitors will be deprived of seeing in their former glory as an evolutionary marvel.

Brazilian children played in the streets of Vila de Natividade with glowing things in their hands as botanist George Gardner visited in 1839. At first, he thought they were fireflies, but soon learnt that they were glowing mushrooms known locally as "flor-de-coco" (Gardner, 1840). After its "discovery" by science in 1839 the species was simply forgotten, which partly explains its rediscovery in March 2006 (Capelari *et al.*, 2011), although a glowing species makes a much easier target.

In reality, the species was ethnoknown, that is, known to the local people. So, either nobody knew to ask, or they disregarded vital local knowledge and fittingly failed to find the species by themselves. For where it exists, ethnoknowledge of extinct species is often our greatest glimpse into the lost (Burbidge *et al.*, 1988).

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41. When native species must go (*Lampetra minima*)

The Miller Lake lamprey (*Lampetra minima*) had been feeding on the lake's native fish for millennia before prized trout were introduced, providing the world's smallest predatory lamprey with a forbidden temptation. It soon became a pest in its own aquatic home, and in 1958 ichthyocides were introduced to eradicate it from the lake and its tributaries (Miller et al., 1989; Clemens, 2020). The following year a barrier was created to prevent any lampreys in Miller Creek from moving back into the lake and spawning there.

The holotype appears to be the earliest specimen collected (on 20 August 1950), while 34 more specimens were collected on 17 July 1952, which seems to be the last confirmed record of the species. Its retrospective scientific description decades later stated that it was extinct (Bond & Kan, 1973), only one of dozens of North American fish thought gone (Miller *et al.*, 1989; Jelks *et al.*, 2008; Burkhead, 2021).

The species' rediscovery in the Williamson River in 1992 (Lorion *et al.*, 2000) was both relieving and disconcerting in equal measure as the species appears to have been presumed endemic to the lake without justification. After spawning adult lampreys die because by this point they have stopped eating to put all of their energy into reproduction, so it is possible that numbers of dead Miller Lake lampreys regularly went unnoticed for decades.

A second, far more mysterious lamprey existed in Ukraine which remains without a scientific name. A migratory species that was last recorded in the late 1800's after a targeted fishery, it is presumed to have been the larger of a sympatric species pair (with *E. mariae*) (Kottelat *et al.*, 2005). Yet scant written records exist, and no known specimens were ever preserved, which could give us a clearer picture of it. But at least we know that it existed, so we have something to mourn.

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42. Japanese inspired sheep on a British island (*Ovis*)

Sheep have grazed on North Ronaldsay in the Orkneys north of Scotland for hundreds or thousands of years. Maybe even since the Iron Age. However, as the kelping industry which produced soda ash died out the human population turned to agriculture instead. In order to protect their crops from the munching mammals they built a 1.8 m (6 ft) high stone wall, technically a Scottish drystane, around the entire island in 1832. An incredible feat of human engineering as the wall is 19.2 km (11.9 mi) long.

The sheep were thus banished to live on the sea shore where they were forced to scrounge for seaweed. Rather than dying out, however, they evolved several remarkable adaptations. For example, rather than ruminate at night, it is timed to coincide with high tide when it would be more dangerous to attempt to feed.

On the island of Rhum, Inner Hebrides, Scotland, the red deer (*Cervus elaphus*) have been observed for decades eating live seabird chicks. The Manx shearwater (*Procellaria puffinus*) chicks have their legs, wings or heads eaten. The behaviour is suspected to be motivated by mineral deficiencies in the vegetation that the deer normally consume. They have somehow learned that the chicks can be eaten to supplement their otherwise poor diet. This behaviour has also since been observed on another UK island, Foula in the Shetland Islands, where sheep are the culprits, presumably for similar reasons. It has also now been documented in other ruminants, and a species of wallaby (Fitzsimmons, 2016).

Recent research has also overturned the notion that all giant ground sloths were herbivorous, showing that at least one species was an opportunistic omnivore (Tejada *et al.*, 2021). Darwin's ground sloth (*Mylodon darwinii*) was named after Charles Darwin because he collected the material used as the basis for the species' scientific description. Since 1840, a remarkable assemblage of *Mylodon* material has been uncovered including bones, soft tissue and coprolites (fossilised poo).

While all modern sloths are herbivorous, and the coprolites and certain cranial features of giant ground sloths suggest that their extinct relatives were too, isotopic analysis shows that this is not completely true. With at least 50 species of giant ground sloth from the Americas and Caribbean during the Late Pleistocene–Holocene, their ecological role needs to be completely re-evaluated in light of this.

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not an herbivore. Scientific Reports 11: 18944. https://doi.org/10.1038/s41598-021-97996-9

43. Wren is a common name appropriate? (*Xenicus longipes*)

The two living species of New Zealand wrens are in fact a unique suborder Acanthisitti, with all 6,500 other species of passerines (often called perching birds or songbirds) being referable to one of two large suborders: Passeri or Tyranni. At the time of Polynesian colonisation around 1280AD there were around 7 species, with only the two still surviving: the rifleman (*Acanthisitta chloris*) and the rock wren (*Xenicus gilviventris*).

Most species had reduced sterna indicating weak flight muscles, spending most of their time close to the ground, making them vulnerable to the kiore (*Rattus exulans*) and other introduced predators. As with other faunas around the world these extinctions likely happened in two waves, following first Polynesian and then European colonisation.

Only one of the extinct species, *Xenicus longipes* (mātuhituhi or bushwren), survived into the 20th century. It was split into three subspecies, coinciding with New Zealand's three largest islands: North Island, South Island and Stewart Island. Their extinctions likely happened within 20 years of each other, with their last recorded sightings being 1955, 1968 and 1972, respectively (Miskelly, 2013). A poignant colour photo of the Stewart Island subspecies was taken by Don Merton in 1964 during attempts to translocate and thus save it. While two black and white photos of a South Island bushwren and eggs were taken in 1911 by Herbert Guthrie-Smith.

Recent molecular dating suggests that the Acanthisittid "wrens" probably diverged from all other extant passeriformes some 52.7-68.5mya (Mitchell *et al.*, 2016), making the conservation of the last two remaining species not only of international ornithological importance but a global conservation imperative.

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44. Will we ever sea Ivell's anemone again? (*Edwardsia ivelli*)

Widewater lagoon at Shoreham-by-Sea on the West Sussex coast of England is a manmade body of water roughly 1 kilometre (0.62 miles) long and very narrow, with a total area of roughly 7.5 hectares, and an average of 1m in depth. On one side it is flanked by Shoreham beach, a shingle beach that prevents seawater seepage into the lagoon from the ocean. While on the other is a row of double-storey houses that back onto Brighton Road.

It is here that Oxford University zoology graduate Richard Ivell discovered 20 specimens of a tiny sea anemone, which he sent alive to R. L. Manuel in September 1973. Manuel repaid the favour by naming the new species after him. Less than two centimetres long, the oral disc was buff with orange spots, surrounded by three inner tentacles and then 9 outer tentacles. Although there is little information on the species' diet, which presumably included tiny invertebrates.

The species was last recorded a decade later in 1983, and at least three subsequent searches have failed to find it. However, given the small size of the animal and its presumably tiny population (at best), there is a chance that it has been overlooked. Especially since the location of its only known habitat is manmade, so it could conceivably exist in the wider sea adjacent. Although looking for such a tiny creature in such a large expanse of water gives some sense of how hard the job of conservationists can be. Perhaps eDNA can help if enough genetic material from preserved specimens exists.

Given the shallow nature of Widewater lagoon, it is amenable to large-scale changes in salinity level through evaporation which larger bodies of water would not be as affected by. As a result, the brackish lagoon has become hypersaline (Jackson, 1999), which even if it didn't directly affect Ivell's sea anemone, may very well have affected its prey. If it still exists it may only ever be rediscovered by accident. Needless to say, let's hope that happens.

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45. Far from home (*Dypsis carlsmithii*)

How did a Madagascan palm end up in Hawaii around 10,858 miles or 17,475 kilometers away? This might not sound like a big deal since plants are exported to different countries all the time, but when it turns out to be a new species that is unknown in Madagascar itself, the search was on for wild plants.

Originally discovered on the estate of former International Palm Society President Donn Carlsmith, it had flowered and seeds were being distributed around, so it attained the unofficial name *Chrysalidocarpus* 'Stumpy' or *Dypsis* 'Stumpy'. It was eventually described as a new species in 2002, and given the eponymous scientific name *Dypsis carlsmithii* (Dransfield & Marcus, 2002). It has since been located in the wild, although less than 15 mature individuals were known in 2012 (Rakotoarinivo & Dransfield, 2012).

Yet far from being a unique story, the unmitigated collection and sale of Madagascan palm seeds to collectors worldwide has resulted in a number of new species of *Dypsis* being described from cultivated specimens: *Dypsis albofarinosa*, *D. cabadae*, *D. leptocheilos* and *D. robusta* (Hodel *et al.*, 2005; Palmpedia, 2016).

The seeds of various species are often extremely similar despite adult plants being vastly different, while care is not taken by seed collectors to properly identify the species from which they are harvesting seeds, partly because it requires expertise to properly identify palms. While the country is economically poor, forcing people to make money anyway they can. Consequently, recruitment levels for many species are extremely low, and the genus has a disproportionately large number of species which are either feared extinct or have been rediscovered (Humphreys *et al.*, 2019).

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46. What is the ant-swer? (*Plesiorycteropus madagascariensis*)

Madagascar's mysterious Bibymalagasy or Malagasy aardvarks are enigmatic digging mammals that have long puzzled mammologists. Sadly, it is often the most unique species which have gone extinct in recent millennia, with their scant remains making them even more enigmatic.

The first species, *Plesiorycteropus madagascariensis*, was described at the end of the 19th century (Filhol, 1895), while a second species, *P. germainepetterae*, was described 99 years later (MacPhee, 1994). Given some similarities with the true aardvark (*Orycteropus afer*), the only member of the order Tubulidentata, as well as other ant-eating mammals such as pangolins, *Plesiorycteropus* was long considered to be a tubulidentate too for much of the 20th century (Buckley, 2013).

When Ross MacPhee described the second species, he erected a new order (Bibymalagasia) for the two species because most of the traits used to infer a close relationship with the aardvark were simply coincidental adaptations to a shared digging lifestyle.

Such morphological approaches were augmented by the first molecular phylogeny of the genus which found them nested within the Tenrecoidea (golden moles and tenrecs), a relationship not previously even considered. However, a year later another morphological look at the species, this time concentrating on the inner ear bone, found that the order Bibymalagasia should be retained.

Ultimately, until we have the entire genome of both species to compare with that of extant species, their true placement will be as enigmatic as their extinction roughly 2000 years ago (Burney *et al.*, 2004). This will also resolve the question as to whether there really are two species, or whether they represent sexual dimorphism or some other variable that has falsely led them to be treated as distinct.

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47. Let me introduce you to *Oncorhynchus kawamurae*

Lake Tazawa in Akita Prefecture on Honshu is Japan's deepest lake at 423 metres (1,388 ft), and was home to a diverse fish and crustacean fauna during the early 20th century. However, in an attempt to generate hydroelectricity prior to WWII, acidic water from nearby Tama River was introduced in 1940 and killed off all of the fish species except the Japanese dace (*Tribolodon hakonensis*). The lake's only endemic fish, the kunimasu or black kokanee (*Oncorhynchus kawamurae*), thus disappeared.

This ecological disaster appears to have been pre-empted as millions of fertile eyed eggs were introduced to various other lakes on Honshu. But with no further record of the species from any lake on the island in the decades to come, the half-hearted conservation attempt was taken to be a failure. Thankfully, the species was rediscovered in Lake Saiko when 9 fish were collected in March and April 2010. This has allowed a study and comparison with the similar himemasu (*Oncorhynchus nerka*), demonstrating that they are two distinct species (Nakayama *et al.*, 2013).

A second retrospectively successful translocation was discovered in Motosu Lake, although only hybrids were found suggesting that pure individuals may have become extinct (Nakayama *et al.*, 2018). While the species' survival in Lake Saiko was found to be threatened by the introduced European eel (Anguilla anguilla) which was observed digging up the kunimasu's eggs deposited in their preferred gravel beds (Oohama *et al.*, 2020).

In North America, a lacustrine (lake) form of Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) was likewise rediscovered as an introduced population after it had long been thought to have become extinct (Peacock *et al.*, 2017). Unfortunately, there are far more salmonids (family Salmonidae) thought to be extinct, particularly in the genera *Coregonus*, *Oncorhynchus* and *Salvelinus*. But this leads to the possibility that some of them will be rediscovered too, perhaps the result of undiscovered translocations, as salmon and trout species are prized as both sport and food.

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48. A giant in the canopy (*Ctenomorpha gargantua*)

Standing on the forest floor, it is easy to look up at the canopy high above you and see only leaves. Yet these sky islands harbour an immensely diverse fauna that remains rather mysterious. In Australia's northern Queensland rainforest, an enormous female stick insect some 525mm in total length was photographed on 28 March 1996 by Mr. T. G. Fayne-Scott, easily the longest in Australia and completely unknown up to that point.

Then later in 1996 males started to be recorded on average every few years, seemingly attracted to artificial light sources, but no more females were recorded. The species was fittingly dubbed *Ctenomorpha gargantua* (Hasenpusch & Brock, 2006), based only upon preserve male specimens, forced to use a photograph of the original female discovery.

Then in January 2014 Maik Fiedel hit the jackpot after years of failed searching, a pregnant female that had probably been blown down to "only" six metres above the ground. Although she died mere weeks later, as they have surprisingly short lifespans (1–2 years) for such large insects, it was the beginning of a captive breeding program that would allow scientists to better study the species. One of her female young grew to 56cm (males are significantly shorter), later surpassed by subsequent generations at around 58cm in total length. While rumours of another wild female measuring in excess of 60cm exist.

Queensland's other pre-eminently rare canopy-dweller is Coxen's fig parrot (*Cyclopsitta coxeni*), a relatively small (15cm) green enigma that silently feeds on the fruit of native figs (*Ficus* sp.) high in the canopy. It has been the subject of numerous unconfirmed sightings over the last few decades, although verified records do apparently exist (BirdLife International, 2021). It appears to be split into four subpopulations, none of which are of large size, with a total global population estimated at less than 250 mature individuals.

The difficulties in finding and monitoring such a cryptic species make its conservation very difficult, as only broad conservation measures such as habitat conservation and revegetation can be carried out in the absence of an ongoing group to study. While the persistence of reports supports the notion that it is not in immediate danger of extinction, the road to recovery must first be built before it can be navigated.

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49. When extinction is retrospective (*Akrav israchanani*)

Unbeknownst to anyone, the water level inside the undiscovered Ayyalon Cave's lake had dropped about 12m due to domestic use of groundwater over several years. Then in April 2006 a bulldozer working in Nesher quarry at Ramla, Israel accidentally penetrated the cave wall which had by then become a tomb. Scientists found several new species inside, including the exoskeletons of a very distinctive scorpion that was scientifically described (*Akrav israchanani*) the next year and placed in its own taxonomic family (Akravidae) (Levy, 2007).

Then in 2015 Levana Cave was discovered 350 metres away after a similar accident in the quarry, where five more specimens of the species were found (Fet *et al.*, 2017). The use of groundwater was thought to have caused the scorpion's extinction here too. Although as this demonstrated that the two caves were linked, albeit by a passage too small for humans to navigate, the scorpion might survive within another part of the hypothetical cave network.

By the time the giant gecko's significance was recognised, it had been on public display in the Musée d'Histoire Naturelle de Marseille for many years. With a SVL (snout-ventral length) of 370mm it was more than 50% larger than the largest known gecko (family Gekkonidae), yet it did not come with any locality data to suggest its origin. It was probably collected during 1833-1869, a period for which the museum has no records (Bauer & Russell, 1986). As no such living species was known globally, it was probably extinct. It was given the scientific name *Hoplodactylus delcourti*, and tentatively assigned a distribution on New Zealand's North Island. Apart from being most closely related to New Zealand's geckoes, Māori legends of a giant lizard (kawekaweau) from the early 1800's lended some credibility to this.

However, New Zealand is relatively rich in subfossils, so if the species did formerly occur there then surely it would already be known. But as (Bauer & Russell, 1986) noted, not if such material had simply been assumed to belong to the tuatara (*Sphenodon punctatus*), the only comparably sized native lizard. After all nobody had suspected that geckoes can get that large. Yet 35 years later the geographic origin of the world's largest known gecko remains a mystery.

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50. Planting the seed of rediscovery (*Idiospermum australiense*)

In August 1971, four of grazier John Nicholas' cattle were poisoned, and when a further two died shortly after from the same cause he called the police. If it weren't for the discovery of the Wollemi pine (*Wollemia nobilis*) decades later (Woodford, 2002), this would have been the start of the greatest botanical discovery of the 20th century in Australia. Autopsies were conducted on the latter two animals by veterinarian Doug Clague and R. G. Cameron (Inspector of Stock), with botanical material ("seeds") from the gut contents of the cattle and the likely culprit, a large tree in the same paddock with identical "seeds" at its base, sent off for expert examination.

The response from the Queensland Herbarium was that this was the long lost *Calycanthus australiensis* (Idiot fruit or ribbonwood), making it the botanical find of the century at the time. The farmer had already cut down the rediscovery tree to prevent any further bovine losses. Thankfully, a number of other trees were found in the local area, and a second locality was later discovered where it was locally common (Blake, 1972). Perhaps most remarkable was the fact that the species grows to 40m in height, and hence was essentially hiding in plain sight.

It has several unique, often described as "primitive", features that set it apart from most modern plants, which represents its ancient lineage. The seeds are relatively massive at around 80mm (3.15 inches), which split into four quadrants at germination, whereupon potentially multiple shoots grow, each with between 2 and 6 cotyledons (seed leaves). The Musky rat-kangaroo (*Hypsiprymnodon moschatus*) may occasionally disperse seeds some short distance, but otherwise any major seed disperser (megafauna) must now be extinct.

Instead, gravity is today given the job of helping ensure the species' survival, which appears to be the reason that the species is found in dense stands of up to 100 trees. It is the only member of its family (Calycanthaceae) in the southern hemisphere, with less than a dozen other species distributed in China and the USA. Along with fossils of the family from South America, this suggests a Gondwanan origin (Zhou *et al.*, 2006). Other large trees that have been rediscovered include the Dawn redwood (*Metasequoia glyptostroboides*) (50m) and *Kalappia celebica* (40m).

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51. "What a big mouth you have" (*Megachasma pelagios*)

Most new species discovered are relatively small, yet large animals also remain to be found. The Megamouth shark (*Megachasma pelagios*) was famously only discovered in 1976 after being caught in the sea anchor of a US navy ship, and still remains known from only around 100 specimens. Yet many of these records have been of beached specimens that washed ashore, so many specimens prior to 1976 must have either gone unfound, were too decomposed to identify when found, or were found by people who did not or could not report their find to scientists.

Thus, it is a virtual certainty that the species was encountered by prehistoric people around the world long before taxonomy was formally introduced in 1753 for plants and 1758 for animals. Similarly, the insect family Mantophasmatidae was only discovered in 2001, with several dozen species described since then. Again, these species were likely long encountered by people, with science lagging considerably behind.

The sixth Megamouth encountered was tagged, providing scientists with two incredible days' worth of data (Nelson *et al.*, 1997). As one of three filter-feeding sharks (along with the Basking shark and Whale shark), its evident behaviour in rising to close to the surface at dusk/night and then diving deep during the dawn/day coincides with the movement of the plankton that it feeds upon. As a species that stays down deep during the day and is not interested in the bait fisherman invariably use at night, it is no wonder than no recreational fisherman has ever caught one on a hook and line. Partly, though clearly not fully, explaining the paucity of records of the species.

But perhaps the most enlightening lesson connected to the species involves the third known specimen which washed ashore at Mandurah, Western Australia in 1988. The dying animal had been seen close to shore by surfers the previous day, who upon thinking it was a whale in danger of beaching itself tried to herd it out to sea (Berra & Hutchins, 1990).

With a round and broad head more reminiscent of a whale than a shark, this misidentification is somewhat understandable. The inherent difficulty in identifying marine animals from the surface is made more acute by inexperience and overall morphological similitude. But while most large marine animals discovered today are the result of the discovery of cryptic diversity (e.g. oceanic sunfish, manta rays), species which look virtually identical to known ones but are genetically quite distinct, it is possible that truly novel large species remain to be discovered (Woodley *et al.*, 2008).

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52. An extinct sheep-sized echidna (*Zaglossus hacketti*)

Living monotremes are represented by the platypus (*Ornithorhynchus anatinus*) and four species of echidna in two genera (*Tachyglossus* and *Zaglossus*). Baby echidnas are known as 'puggles', but despite also often being called puggles baby platypuses have no technical name. Though 'platypup' is justifiably popular.

In addition to the above living species, two fossil echidna species are known to have survived until the last 100,000 years (Johnson *et al.*, 2006). Owen's echidna (*Megalibgwilia owenii*) was 60cm (2ft) long and 10kg (22lbs), comparable in size to today's largest species in the genus *Zaglossus*. But the aptly named Hackett's giant echidna (*Zaglossus hacketti*), stood half a metre tall (1.6ft) and weighed about 30kg (66lbs), about the size of a young sheep. How similar in behaviour these two extinct species were to their surviving relatives is unknown, as relatively few fossil remains have been found (Murray, 1978).

In the absence of evidence of a giant extinct ant species from the Australian Late Pleistocene, the ants that Hackett's giant echidna fed on would not have been much larger than that eaten by extant echidnas. Their voracious appetite would have required many more ants to fill them up, which probably wasn't a problem as they must have been far more powerful diggers. Yet it is unclear why Hackett's giant echidna was so much bigger than other recent species of echidna. It may have been an opportunistic move to fill an open ecological niche, or it may have been to reduce competition with other species by targeting different ecological resources, or it may have been for some other reason such as a greater ability to travel longer distances in search of food. But all of this is pure speculation at this point.

It is also possible that they formed echidna 'trains' as extant species do (Rismiller & Seymour, 1991), with a line of hopeful males following a female in single file until all but the most persistent one remains. While one living species from New Guinea, Attenborough's echidna or the Cyclops long-beaked echidna (*Zaglossus attenboroughi*) has not been seen since 1961 when the only known specimen was collected. However, echidna sign and local knowledge suggest that the species still survives despite only a single scientific record of it (Baillie *et al.*, 2009).

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53. A very slender chance of survival (*Numenius tenuirostris*)

The extinction of the Eskimo curlew (*Numenius borealis*) is one of the iconic losses of 20th century ornithology, so the thought that it could be allowed to happen again to another curlew within decades is unconscionable. Most curlew species (*Numenius* spp.) are migratory, meaning that they potentially face different threats along their migratory route. But the Slender-billed curlew's (*Numenius tenuirostris*) breeding range is all but unknown, with retrospective analysis of stable isotopes being one of the few lines of investigation that may shed some light on the matter (Buchanan *et al.*, 2017).

Instead, its catastrophic decline was orchestrated by overhunting on its wintering grounds around the Mediterranean, which is an area notorious for the mass killing of birds (McCulloch *et al.*, 1992; Brochet *et al.*, 2016) and presumably habitat loss. It went from very common at the beginning of the 19th century to small flocks by the mid-20th century, and went from around 300 birds recorded during the period 1980-1990 to half that during the next decade (BirdLife International, 2018).

The twitching community went wild for any alleged report of the species, with birders flocking to get a glimpse of an almost extinct species. The last recorded individual is disputed, though the last nationally accepted record is from Hungary in April 2001 (Oláh & Pigniczki, 2010), making it possibly one of the earliest new millennium extinctions.

An exhaustive series of surveys were carried out during 2009-2011 that failed to find any remaining birds (BirdLife International, 2018), and any remaining population would truly be tiny (<50 birds). This has led to a retrospective reassessment of many historical records of the species (e.g. Kirwan *et al.*, 2015; Hudeček, 2016), as we begin the grieving process by first orientating ourselves to look backwards through time. This can be supplemented by eagle-eyed researchers who recognise the importance of small details that can have big implications (Baccetti, 2001). Every extinction is a potential lesson, but we have to want to learn from them before we can hope to prevent further losses.

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54. The sting of extinction (*Hylaeus* sp.)

Species density among taxonomic groups can vary greatly depending in part upon whether the speciation (the evolution of new species) was due to geographic isolation (*allopatric speciation*) or not. In rare instances, radiations of species can arise where the principal driver is not geographic isolation but rather partitioning into acute ecological niches that reduce intraspecific (between species) competition and thus promotes flourishing of all proto-species involved.

The only genus of bees native to the Hawaiian Islands is *Hylaeus*, where approximately 60 recent species are known, although almost a dozen have not been recorded in decades and may be extinct (Magnacca, 2007). A total number of species that exceeds that in the entire North American continent. Yet they are believed to derive from a single Asian ancestor that diversified into many different forms that collectively range over virtually every elevation of every island within the archipelago.

And yet they have largely been neglected from a conservation standpoint, even though as natural pollinators the major extinction of Hawaiian plants due to habitat destruction and introduced herbivores has rendered their mutually beneficial relationship in serious peril. Given their soft bodies they do not readily fossilise, so knowledge of any Late Pleistocene or pre-European extinctions that may have taken place will almost certainly never be recovered. Unfortunately, native bee species all over the world are threatened by the introduction of the European honey bee (*Apis mellifera*) (Goulson, 2003; Yang, 2005; Prendergast & Ollerton, 2021).

The extinction of unknown species of Hawaii's other invertebrate groups can be inferred, such as a presumably extinct species of *Philodoria* moth whose existence is suggested by unique damage to herbarium specimens (Johns *et al.*, 2014). While one Hawaiian plant, *Brighamia insignis*, is extinct in the wild partly because its presumed obligate pollinator (as no extant pollinator does a great job) is extinct (Walsh *et al.*, 2019).

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55. Going bananas for *Musa fitzalanii*

The William Cavendish bananas that you often see in supermarkets (and have probably eaten) are all clones of each other: they are genetically identical, despite idiosyncratic differences in shape, size, etc. that arise as they are growing on the plant. This makes the cultivar (cultivated variety) susceptible to extinction as all individuals are equally prone to disease.

Until the 1950's another clonal variety, the Gros Michel, was the predominant export banana due to its tastiness and thick skin which prevented bruising during transport. However, many plantations were wiped out by Panama disease and it is today grown in much small quantities (often under different local names) than the ubiquitous William Cavendish which usurped the former's top position. As with other fruits and vegetables, there are many older varieties of bananas that are much tastier than the simple supermarket selection, but for various reasons cannot be cheaply and conveniently grown in enormous quantities to satisfy the market.

The genus *Musa* contains around 70 wild species of bananas, of which half a dozen species have been rediscovered (all in India), with two species missing and hence possibly extinct. One of these, *Musa paramjitiana*, is native to the Andaman and Nicobar Islands of India but has not been seen since 2013 (Singh *et al.*, 2020). The other species, *Musa fitzalanii*, is only known from a single specimen collected in or before 1875 in north-eastern Queensland's Daintree rainforest by the eminent botanist Ferdinand von Muller (von Mueller, 1875). Despite growing to six metres, it has never been recorded again and is considered extinct (Humphreys *et al.*, 2019).

The conservation status of many of the world's wild edible plants is precarious, as habitat destruction replaces them with crops and orchards of their domestic descendants that have been selected for their superior size, taste, yield and hardiness. While the ancestors of some of today's domestic food plants are unknown and may be extinct. The peach, faba bean and onion all have no known extant ancestor (Zheng *et al.*, 2014; Rottenberg, 2020; Chen, 2021).

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56. Schrödinger's clouded leopard (*Neofelis nebulosa brachyura*)

The rise of social media has greatly helped spread the conservation message, but it also has the potential to spread misinformation. Almost every week for the past six months I have seen a story on Facebook reporting that the Formosan clouded leopard (*Neofelis nebulosa brachyura*), native to the island of Taiwan (formerly Formosa), has been rediscovered. In reality there have been unconfirmed reports of its continued existence. But if there is a real feline that embodies Schrödinger's zombie cat, both alive and dead (refer to the popular physics literature for an accurate explanation), it is Taiwan's ghost leopard.

There is no doubt that the island's clouded leopard population was real, as evidenced by teeth dating to the Late Pleistocene which are larger than recent populations (Gan *et al.*, 2016), with the last confirmed record often cited as 1983 (Rabinowitz, 1988). Yet the taxonomic status of these animals is disputed. The subspecies was described (Swinhoe, 1862) based upon a trade skin with an incomplete tail of uncertain geographic origin, with no other diagnostic characters in any other allegedly Taiwanese specimens vouching for its distinctiveness, thus the nomen *Neofelis nebulosa brachyura* is currently considered invalid (Kitchener *et al.*, 2017 and references therein). So, in a sense the Formosan clouded leopard is dead.

Yet there is little doubt that the clouded leopard was native to Taiwan until less than a century ago. And since the subspecies is invalid, the population must belong to another subspecies, or, the species should be regarded as *monotypic*. With little evidence for any subspecific distinctions within the species at present, the latter is the line taken by (Kitchener *et al.*, 2017). Thus, the Formosan clouded leopard, as a geographical population disassociated from its historical trinomial, still exists elsewhere within the species' native range in southern Asia. Thus, the Formosan clouded is alive, as well as dead.

Yet there is also a danger here in supposing that because the species exists elsewhere, that therefore the loss of the species from Taiwan was negligible. There are two ways in which this is false. The first and most obvious way is that the ecosystems that it inhabited on Taiwan have been greatly affected as the species' removal as a top predator has had a trophic cascade that affects all other species at lower trophic levels. The second way is more subtle, and regards unique genetic elements that would have rendered the population genetically distinct even if those differences did not require the erection of a new trinomial. As an isolated population occupying an island, thus severing gene flow, the Formosan clouded leopard qualified as an Evolutionarily Significant Unit (ESU), and thus its loss from the island through human hunting and habitat destruction (logging) was all too real.

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57. The grey ghost (*Callaeas cinereus*)

Any surviving members of a taxon declared extinct do not drop dead as a result, nor importantly are all reportedly extinct taxa equally unlikely to be rediscovered. Expert opinion is that the Southern Florida rainbow snake (*Farancia erytrogramma seminola*) was probably declared extinct too soon (https://shorturl.at/qsDT9). As a species becomes progressively rarer, reports of its existence concomitantly dry up and then peter out altogether if the decline continues. It may still exist for long periods at very low, almost undetectable densities (until its actual extinction). And in most cases that is it, with no further unconfirmed reports of its continued existence.

The thylacine or Tasmanian tiger (to choose just two of its 40+ historical common names) stands peerlessly as the species that seemingly refuses to stay extinct. The second most reportedly seen missing/extinct species occurred (or occurs) on an island to the east: New Zealand's South Island. The South Island kōkako (*Callaeas cinereus*) is or was a species of wattlebird in the family Callaeidae, which comprises five recent species all endemic to New Zealand. The species declined like many New Zealand birds from introduced predators such as rats, cats and mustelids (Holdaway, 1999; Holdaway *et al.*, 2001), with the last recorded sighting being disputed but possibly as recent as 1967 (Clout & Hall, 1967).

The Department of Conservation (DOC) declared the species extinct in 2007, forty years after the Mt Aspiring sighting from 1967. Yet the grey ghost may still haunt New Zealand's ancient forests. Milne & Stocker (2014) compiled a list of 241 reports between January 1990 and June 2012, and in an unprecedented move in 2013, the OSNZ Records Appraisal Committee accepted a report from March 2007 (Miskelly *et al.*, 2013) as confirming the persistence of this species. This was followed by BirdLife International who downgraded the species' conservation status to "possibly extinct" in 2016.

The official website of the South Island kōkako Charitable Trust (https://www.southislandkokako.org/) has a distribution map with details of hundreds of reports of sightings and calls up until 2020 that cover hundreds of square kilometres, including Stewart Island to the immediate south. The increase in reported sightings bodes well for the species, yet the complete absence of proof of its continued existence also suggests a fallibility to unconfirmed reports. With its slate grey colouration and elusive call, the species blends into the shadowy forest between myth and reality.

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58. The hide and seek world champion? (*Cherax urospinosus*)

Often species are rediscovered in remote areas away from large human populations, so the story of the Short-tailed rain crayfish (*Ombrastacoides parvicaudatus*) reminds us of how ignorant we are of the natural world.

The inundation of the original Lake Pedder in Tasmania during the early 1970's for hydroelectricity is one of the world's great natural losses of the 20th century, which caused several invertebrate species to disappear. Thankfully, all but the Lake Pedder earthworm (*Hypolimnus pedderensis*) have since been rediscovered, with the latest and perhaps most surprising being the Short-tailed rain crayfish. It was rediscovered in November 2020 in creeks running into Lake Burbury, a popular fishing lake.

Despite their knowledge of freshwater fauna, many fishers must have seen the species but not recognised it. In reality, they can be given some slack as the taxon was only scientifically described in 2006 (Hansen & Richardson, 2006) and virtually nobody even knew that it was missing. Yet somebody could have asked for an expert ID of the strange crayfish, so even if they didn't know it was missing their inability to identify it may have resulted in its rediscovery earlier.

Part of the problem here is that to the untrained eye freshwater crayfish (like many taxonomic groups, such as snails) may appear superficially similar. So, it is less surprising than it may seem that two new species of freshwater crayfish were discovered in the popular tourist destination of the Whitsundays in Queensland in 2012 (Coughran *et al.*, 2012).

With all of that as background, a real contender for the world hide and seek champion is the freshwater crayfish *Cherax urospinosus* that has putatively only been found once, in a concrete drain in the Queensland suburb of Indooroopilly within the capital city of Brisbane, before 1970 (Riek, 1969; Austin, 2010). Given the artificial location where the male holotype specimen was found, its native distribution must either have been destroyed or lies elsewhere. In researching for this account, I found that the Australian Museum actually holds two specimens (https://shorturl.at/ikvI9), with a female identified in 1971 though without locality data.

As freshwater crayfish look very similar to all but carcinologists, it is perfectly possible that the species still exists, and may unknowingly have been encountered many times by members of the public, but remains to be formally rediscovered.

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59. Digging the dirt on giant earthworms (*Megascolides australis*)

There are many stories of giant Anacondas in the Amazon, their huge weight supported by the water they swim through. In various places around the world, giant earthworms of relatively comparable size burrow through the soil, dirt snakes if you will. In 1967 in South Africa, the largest recorded earthworm specimen (6.7m or 22ft), belonging to *Microchaetus rappi*, was found next to a road after heavy rains which bring them to the surface. They are most often found on the Karoo and in the Eastern Cape, and though they are regularly found their conservation status is not well understood.

Australia's smaller Gippsland giant earthworm (*Megascolides australis*), still of immense proportions for an earthworm, is much rarer and is the subject of ongoing protection. They are thought to have declined due to the use of pesticides, with an already naturally restricted distribution due to complex series of interrelated factors (van Praagh *et al.*, 2007). They are famous for the squelching noises they sometimes create as they make their way through their water-filled burrows half a metre below the ground. The difficulty in studying these giants means they still retain many of their subterranean secrets.

Earthworms, like most taxonomic groups, have been hit by anthropogenic extinctions. The respectively earliest described species from New Zealand (*Tokea orthostichon*) and Japan (*Amynthas japonicus*) have both been declared extinct (Blakemore, 2012,2019a, b). The Giant Brazilian earthworm (*Rhinodrilus fafner*) is known from a single specimen 2.1m (6.89ft) in length collected in 1912 (Michaelsen, 1918), and was declared extinct by the Brazilian Government in 2003.

While four other of New Zealand's earthworms are possibly recently extinct: *Aporodrilus mortenseni* (last record 1915), *Maoridrilus felix* (two subspecies, both first and last recorded in 2010), *Octochaetus levis* (last record 1876) and *Octochaetus microchaetus* (last record 1876) (IUCN, 2021), giving it the unenviable claim to the global earthworm extinction hotspot. And those are just the species that were collected, with the possibility that many others have disappeared globally without ever having been recorded. Thankfully, the news is not all bad. All three annelid worms that have disappeared from Europe (all polychaetes) have since been rediscovered, and four other species (three American, one Indian) have also been re-found (REPAD, 2021).

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60. Some like it hot (*Nymphaea thermarum*)

Like virtually every taxonomic group, species of water lily are still being discovered. The 'plant messiah' Carlos Magdalena Rodriguez found a new species in Australia's Top End (Erice, 2018). More importantly, he has played a vital role in saving perhaps the world's strangest (and smallest) water lily from extinction (Magdalena, 2018). In contrast to the giant *Victoria amazonica* with leaves up to 9ft across, the miniature *Nymphaea thermarum* could theoretically be grown in a tea cup.

The German botanist Eberhard Fischer was studying the vegetation of the Albertine Rift in Rwanda when his car broke down at the hot spring Mashyuza in 1987. Over several days he became acquainted with a tiny water lily that grew there in the overflow, away from the 40°c water at the hot springs' heart. He searched a further 50+ hot springs but failed to find another population. Taking both herbarium specimens as well as live plants back to Mainz University and Bonn Botanic Gardens, he described the species the following year (Fischer, 1988). From here it was a slow decline towards extinction until one man, Carlos, became its saviour.

When the only horticulturalist at Bonn Botanic Gardens who knew how to grow the species retired without telling anyone, the botanical stakes were raised immeasurably. The seeds could be germinated, but the seedlings would soon die before they produced a new generation of plants. Then in 2008 the species' only known wild habitat was destroyed as the hot springs' water was used by farmers. Then the last living plant at Bonn was eaten by a rat that had got into its greenhouse. Unaware of these last two near-fatal blows, Magdalena had been experimenting with trying to grow the species past its first few seed leaves. Yet no permutation of conditions (water level, PH, sunlight etc.) was working, and he was quickly burning through the irreplaceable seeds.

The epiphany came to him as he was at home stirring his tortellini pasta: the plants needed more CO2 (carbon dioxide). His next iteration of trials allowed the seedlings' leaves to rise to capture greater amounts of carbon dioxide. With one very serious hiccup, involving the theft of one of the plants from Kew in 2014, the species has made a remarkable recovery. Though without its original habitat intact, reintroduction is currently very unlikely in the short-term.

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61. Seeing double (*Bootherium bombifrons*)

The true number of recent extinctions is underrepresented by preserved specimens as many species and subspecies have never been collected or found. Yet simultaneously, the number of accepted recent extinctions is higher than justified. Firstly, because some species have been declared extinct even though they are extant, and secondly because (sub)species that never existed are mistakenly thought to have become extinct (see No. 2).

One particularly illustrative example of the latter is the Woodland musk ox (*Symbos cavifrons*), a species that was thought to have become extinct from North America during the Late Pleistocene. Not only was it considered a valid species, but it was placed in a different genus than the extant musk ox (*Ovibos moschatus*) and extinct *Bootherium bombifrons* and *Gidleya zuniensis*, indicating that it was very distinct indeed.

However, McDonald & Ray (1989) undertook a comprehensive analysis of these species and found that *Symbos cavifrons* is a junior synonym of the earlier described *Bootherium bombifrons*. It turns out that *B. bombifrons* was described based upon a female specimen and *Symbos cavifrons* represents the male of the species, which explains why they were found together so frequently. This was backed up with molecular evidence two decades later (Bover *et al.*, 2008). So sexual dimorphism (physical differences between females and males) in the fossil record may artificially inflate the number of extinctions.

But this kind of mistake is not limited to long dead and incomplete specimens. It also took place at least once among living birds. The adult females and males of the Huia (*Heteralocha acutirostris*), a species of wattlebird (family Callaeidae) from New Zealand (see No. 57), were described as two different species due to remarkable differences in bill-shape in adult birds (Gould, 1837; Buller, 1871; Lambert *et al.*, 2009; Tomotani *et al.*, 2021). They were prized for their feathers by the native Māori (Houston, 2010) and appears to have always had a restricted distribution to the mountain ranges in the south-east of the North Island.

As early as 1871 ornithologist Walter Buller lamented the future extinction of the species: "erelong it will exist only in our museums and other collections". Habitat destruction for farming diminished this already small range, while its habit of descending to the ground and hopping made it an easy target for introduced predators (weasels, stoats, ferrets etc.), as specimens were shot for their tail feathers (fashion), skins (taxidermy) and beaks (brooches) in the late 19th century. There is a story that a Māori woman placed a tail feather in the hat band of Duke of York (later King George V) upon a visit in 1901, thus greatly increasing the desire for such a fashion accessory and sealing the species' fate.

However, recent research indicates that the last confirmed record of the species is likely around 1905 rather than the ubiquitously cited 1907 (Galbreath, 1907), and the species was already on a precipitous decline. It is more likely that it was the straw that broke the camel's back, although there were sporadic reports until the 1930's (Lambert *et al.*, 2009) while 1961 is often cited as the last unconfirmed sighting. In

1953 William Phillips began researching for The Book of the Huia published a decade later, and he was able to interview those who saw living birds (Phillips, 1963), something we can no longer do.

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62. Iriomote, a remote feline (*Prionailurus bengalensis iriomotensis*)

Japan was home to two wolves, the Hokkaido wolf (*Canis lupus hattai*) and Honshu wolf (*Canis hodophilax*), until around a decade before and after the turn of the 20th century, respectively (Walker, 2008). Today it is still home to its two native wildcats (and two bears), the Tsushima wildcat and the Iriomote wildcat, from their respective islands. The Tsushima wildcat is Japan's only population of the subspecies *Prionailurus bengalensis euptilura* otherwise native to the Far-East, which has probably been isolated for about 90,000 years due to rising sea levels (Masuda & Yoshida, 1995).

While the Iriomote wildcat (*Prionailurus bengalensis iriomotensis*) is endemic to Iriomote island (part of the Yaeyama Islands), although it's possible that its distribution included other islands in the past, and has been genetically isolated from the other subspecies of *Prionailurus bengalensis* for about 200,000 years (Masuda & Yoshida, 1995). An undescribed species of *Niviventer* (murid rodent) became extinct during the Holocene (<11.7ka) on both Ishigaki and Yonaguni islands (Nishioka et al., 2016), also part of the Yaeyama islands (which along with the Miyako Islands comprise the Sakishima Islands in the Ryuku Islands), thus emphasising the region's relatively longer isolation than the Tsushima archipelago and consequent uniqueness of its fauna.

Iriomote Island is around 284–290 km² (sources vary), making it the second largest island in Okinawa Prefecture (roughly the southern half of the Ryukus), and home to a small human population of around 2,500 people many of whom speak a dialect of Yaeyama. They were aware of the Iriomote wildcat, which they called yamamayaa or yamapikaryaa, long before science found out about the feline in the early 1960's. Only after a group of children and their teacher from Ōhara Elementary School captured an injured male at the miniature Maaree Waterfall in May 1965 did science get its holotype, which became the basis of the species' description (Imaizumi, 1967), since reduced to a subspecies of the Leopard cat.

It is unique among small felids for the diverse range of prey it consumes, frogs, skinks, snakes, birds and insects (Nakanishi & Izawa, 2016), and prefers lowland areas where it comes into contact with humans. It is threatened by hunting/trapping, vehicular accidents, competition/hybridisation with domestic cats and diseases/parasites. It now only numbers around 100 animals, although it is intensively studied and protected so that further decline has been arrested for the time being. But as long as the human population remains occupying its preferred habitat, it will be in a battle to co-exist alongside so many threats.

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63. A deadly radiation of skinks (Mabuyinae sp.)

Extinction is invariably retrospective, as there are very few cases where the death of an endling (the last of its kind) has been actively reported. This is most obvious when considering fossil species, but due to our need to discover species (even if not scientifically described) before we can know anything about them (including their conservation status) almost all anthropogenic extinctions are retrospective. The last Cozumel thrashers (*Toxostoma guttatum*) and Bahama nuthatchs (*Sitta insularis*) may have died from hurricanes that hit their respective islands this millennium, with no humans in sight during their presumed last hours, as neither have officially been seen since (although their extinction trajectories may have been historical and more complex) (BirdLife International, 2020; Levy & Cox, 2020).

On the islands of the Caribbean a new skink fauna was documented in a monograph by Dr. S. Blair Hedges and Dr. Caitlin E. Conn (Hedges & Conn, 2012). They used new characteristics to untangle and distinguish between the many species that had long been lumped together (many under *Mabuya mabouya* which they found was in fact extinct!) to bring to the fore this hidden diversity in the subfamily Mabuyinae. In all they erected 13 new genera and described 24 new species, many of which were already probably extinct due to introduced species and habitat destruction. In total 39 species were recorded as occurring in the Caribbean region, 38 of which are endemic.

Five of the 39 species (12.8%) they described are only known from historically collected museum specimens from the 19th century: *Capitellum mariagalantae*, *Capitellum parvicruzae*, *Copeoglossum redondae*, *Mabuya guadeloupae* and *Spondylurus haitiae*. While five other species (12.8%) originally described by other authors also seemingly disappeared during the 19th century: *Alinea lanceolata*, *Alinea luciae*, *Capitellum metallicum*, *Mabuya mabouya* and *Spondylurus spilonotus*. So, 10 out of 39 species were likely lost during the 19th century, which equates to 25.6% and left 29 species still extant.

The decline of Caribbean skinks continued unabated into the 20th century as seven out of the 29 species (24.1%) have their last confirmed records here, including the relatively recent disappearances of *Mabuya cochonae* (early 1963), *Mabuya montserratae* (1984), *Spondylurus lineolatus* (1985), *Spondylurus martinae* (c. 1965) and *Spondylurus monitae* (1993). Of course, these are only the extinctions that are known or suspected to have taken place, with others possibly yet to be retrospectively discovered via museum specimens or (sub)fossil deposits.

Thankfully two species, *Mabuya berengerae* and *M. pergravis* have been rediscovered (Caicedo-Portilla, 2014) and others may follow such as *Spondylurus martinae* which may have been observed on 10 March 2013. Yet the fact is that this once diverse skink fauna is now a shadow of its former self, and one is left wondering whether some of them would have been saved if they were recognised as unique species rather than considered mere populations of more widespread species.

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64. When to declare? Cricketers and conservationists share a problem (*Rhachistia aldabrae*)

The concept of extinction has two distinct senses. The first is the objective sense in which an individual, group, species etc. ceases to exist. The second and far more tenuous sense is in applying the concept to a given individual, group, species etc. on the belief (or with the knowledge) that it no longer exists. As the many species which have been declared extinct and have been later rediscovered illustrates (e.g. Dong *et al.*, 2015), maintaining this distinction is crucial.

A large portion of the problem is in interpreting and weighting negative evidence, such as the failure to find a target during an expedition and quantifying the effects of habitat loss. Part of this is in knowing both how methodologically appropriate the survey methods were (or weren't) and how extensive the search was relative to the known or suitable habitat. Which is itself based upon both biological (life history, circadian rhythm etc.) and ecological (trophic niche, habitat requirements etc.) data. Otherwise, a taxon should be regarded as data deficient, which is equivalent to agnosticism.

Before the reported extinction of the Bramble Cay melomys (see No. 7), a climate change controversy took place on the tiny granitic Seychelles islands east of Africa in the Indian Ocean. A paper by Justin Gerlach reported the extinction of the Aldabra banded snail (*Rhachistia aldabrae*) following extended periods of drought, with no juveniles seen since 1976 and the last adult seen in 1996 (Gerlach, 2007). Unbeknownst to almost anybody, a paper was submitted shortly thereafter to the same journal written by Clive Hambler and co-authors which contested Gerlach's declaration of extinction and predicted that the species would be rediscovered in the future.

Following the rediscovery of the species in August 2014, the editor of the journal, Richard Battarbee, published an editorial updating the situation. Clive Hambler had reached out to him following news of the rediscovery and requested Gerlach's original paper from 2007 be formally retracted. Battarbee declined the request and clarified that because Gerlach's conclusion that the species was extinct was based upon the available evidence at the time his paper should stand even though it has now been overturned (Battarbee, 2014).

Leaving aside the specific case of the Aldabra banded snail (which I am uncertain as to who is right), declarations of extinction in general function as a means to focus conservation attention by removing almost certainly extinct populations from the scope of active conservation. There becomes a particular point at which the survival of a species or subspecies (or population etc.) is so unlikely that it no longer makes sense to make a concerted effort to try to save it when there are so many other (sub)species that need help. Even though there is an element of uncertainty and there is always a chance that it will be rediscovered, at which point every reasonable effort should be made to save it from the fate it was assumed to have already befallen.

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65. The conifer that formerly spruced up North America (*Picea critchfieldii*)

Larger animals are more prone to extinction, all other things being equal, because of a suite of related characteristics: longer lived, slower reproducing, fewer offspring etc. Though smaller species in low-energy environments are also prone (see No. 24). Yet this does not seem to be the case for plants, as relatively few trees are believed to have recently become extinct compared with their smaller cousins (shrubs, woody vines/lianas etc.). Although this is actually reversed for Late Pleistocene (126–11.7ka) extinctions.

Two such tree extinctions have been known for decades: *Banksia kingii* (Jordan & Hill, 1991) and *Picea critchfieldii* (Jackson & Weng, 1999). With a number of recent additions to this list: *Bastardiopsis palaeodensiflora* (Ramos *et al.*, 2017a), *Paraoxystigma concordiensis* (Ramos *et al.*, 2017b), *Gossweilerodendroxylon palmariensis* (Ramos *et al.*, 2017b) and *Bignonioxylon americanum* (Moya & Brea, 2018). While only one non-tree plant is recorded as having become extinct during the same period: *Potamogeton sukaczevii* (see Field & Lewis, 2018).

Fossil cones and needles from an undescribed species from the genus *Picea* (the spruces) were described as *Picea critchfieldii* from the south-eastern USA (Jackson & Weng, 1999). Previous reports of the genus *Picea* in Georgia were referred to *P. critchfieldii* which extended the species' distribution to more than 240,000 sq km (92,665 sq mi) during the Last Glacial Maximum (LGM) from 25–19kya. However, severe climatic changes were to follow that likely resulted in the species' extinction (glacial/inter-glacial cycles) (Jackson & Overpeck, 2000), and it is last recorded around 12ka and was probably extinct by 10ka (Jackson & Weng, 1999).

Such a decline may seem slow, especially if compared with the speed of anthropogenic extinctions, but by evolutionary standards it was very fast. Millions and millions of trees slowly died out at a speed greater than that at which they evolved in the first place. While a decade and a half after the species' formal description, fossil pollen from the Tunica Hills was referred to *P. critchfieldii* allowing further study of the species beyond cones and needles (Mander *et al.*, 2014). While the extinction of a North American tree during the late Quaternary is currently unique, there may have been others that have so far been "masked by the coarse taxonomic resolution of pollen data and the paucity of detailed studies of pre-Holocene floras in North America" (Jackson & Overpeck, 2000).

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66. A ghost lineage? ("*Ikanogavialis*" *papuensis*)

Insular (island) species are prone to extinction given their very limited distribution which results in a lower population size (generally speaking) and thus they cannot sustain comparable declines to their mainland counterparts. A situation magnified by the fact that islands offer extremely limited opportunities for the fossilisation of these remarkable and often enigmatic taxa.

An excellent example of this is "*Ikanogavialis*" *papuensis* which was described by Charles De Vis as a species of gharial (*Gavialis papuensis*) from Murua (=Woodlark), Papua New Guinea. Ralph Molnar studied the holotype (probably Late Pleistocene/Holocene in age) and concluded that the species is actually mostly closely related to members of the genus *Ikanogavialis* (subfamily Grypsuchinae) which are otherwise no younger than the Miocene (23.03 to 5.333mya), but the remains are too fragmentary to be certain (Molnar, 1982).

The subfamily Mekosuchinae (fully terrestrial crocodiles) on the other hand definitely became extinct during the Holocene, with at least five of its members surviving until at least 126ka. The known global fossil record of the subfamily is restricted to Australia from the Eocene (56 to 33.9mya; 48.6mya to be precise) to the Middle Pleistocene (781ka to 126ka), which does not necessarily reflect the subfamily's actual distribution. With one Late Pleistocene record and several Holocene records from the Pacific Islands of Fiji, New Caledonia and Vanuatu.

The two Australian species *Quinkana fortirostrum* and *Paludirex gracilis* became extinct sometime during the Late Pleistocene but their exact extinction chronology is not tight (Ristevski *et al.*, 2020). The other monotypic (single taxon) genus, *Volia* (i.e. *V. athollandersoni*), is known from two records (one Late Pleistocene, one Holocene) from Viti Levu (Fiji) (Molnar et al., 2002). While the type genus *Mekosuchus* is known from two species, *M. inexpectatus* and *M. kolpokasi*, from New Caledonia and Vanuatu respectively. They are also the youngest known species of the subfamily and probably survived until human occupation of their respective islands (Anderson *et al.*, 2010). While their anthropogenic extinction has not been proven, it is a plausible pattern that occurs in countless other places around the world of species extinction shortly after human arrival.

Unfortunately, most of their biology and ecology is unknown which must have been unique given their terrestriality and insular prey base (for three of the species). Other extinct crocodilians include *Aldabrachampsus dilophus* (Seychelles) and *Voay robustus* (Madagascar) (Brochu, 2006; Hekkala *et al.*, 2021), while more may yet be discovered as the need to re-evaluate the crocodilian fossil record is clear (Brochu & Sumrall, 2020).

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67. A unique animal lumped with another species (*Nilopegamys plumbeus*)

The Ethiopian amphibious rat (*Nilopegamys plumbeus*) is known from a single specimen collected by Wilfred Osgood in March 1927 in a trap from near the source of the Little Abbai river in the Ethiopian highlands. It was found in an area that was already degraded, and possessed unique aquatic adaptations such that Osgood had never seen a rodent like it. Yet it was quickly lumped in with *Colomys goslingi*, another aquatic-adapted species that is closely related, and consequently was not searched for again for decades.

The species was only resurrected from the synonymy of *C. goslingi* almost seventy years later (Kerbis Peterhans & Patterson, 1995), with at least four unsuccessful searches for the species since then (Kerbis Peterhans & Lavrenchenko, 2008; Kostis *et al.*, 2020). The type locality where the holotype was collected has been completely transformed (see Kostin *et al.*, 2020 for a photo) and there is every chance that had that individual not become trapped the species would have disappeared without scientific record. No local knowledge of the species appears to have been reported either, although Ethiopians themselves must have encountered it on many different occasions. If only its uniqueness was not obscured for decades, it may have been saved.

Despite rodents and bats being the predominant new species of mammals described every year they retain a certain level of morphological conservatism. Along with relatively little collecting interest and habitat destruction, this makes many of Africa's rodents enigmatic, with some possibly extinct. Cheesman's vlei rat (*Otomys cheesmani*) is a recently described species (Talyor *et al.*, 2011) known from specimens collected in 1937 from very close to where *Nilopegamys* was collected. The holotype of the Giant thicket rat (*Grammomys gigas*) was collected on 28 December 1910 on Mt Kenya, with a second specimen collected around the same time prior to the species' scientific description (Dollman, 1911). The Mt. Kahuzi climbing mouse (*Dendromus kahuziensis*) is another African highland rodent that is missing, seemingly last recorded on 21 January 1972 (Dieterlen *et al.*, 2013).

Not all hope is lost for Africa's elevated rodents though. The rare Mt Oku hylomyscus (*Hylomyscus grandis*) was for decades known from the 1967 type collection, but has now been collected twice this millennium (Kennerley, 2018). And the Ethiopian striped mouse (*Mus imberbis*) was photographed alive in November 2012 after going missing since 1980, though probably due to previously inappropriate survey methods (Meheretu *et al.*, 2014).

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68. From rediscovered to pest (*Notopala sublineata hanleyi*)

Rediscovered taxa are invariably rare, partly explaining how they disappeared for an extended period of time, and hence usually don't pose any serious threat to us. The River snail (*Notopala sublineata*) comprises three subspecies, including the widespread *N. s. alisoni*, and has been an economically important food source for Aboriginal people in the Murray-Darling River Basin for thousands of years (Garvey, 2017).

The other two subspecies, *N. s. sublineata* and *N. s. hanleyi* on the other hand have suffered severe declines since the 1950's due to flow regulation of rivers and the introduction of European carp (*Cyprinus carpio*) and both are now extinct in the wild. They inhabit irrigation pipelines, with *N. s. hanleyi* being rediscovered in one in 1992, where they are considered pests by farmers when "in such large numbers that they blocked pipes, pumps and sprinklers and fouled the water when they died from lack of oxygen when the pumps were stopped" (https://shorturl.at/qDLO2). Conservationists want to breed insurance populations against total extinction but do not have direct access to many of the pipes that the snails inhabit, forced to collect specimens that have been flushed with chlorine and such.

As members of the family Viviparidae, they give birth to live young (viviparity), which is otherwise rare among snails. They are benthic (bottom-dwelling) and lack a planktonic larval stage that would otherwise increase their rate of dispersal when young. Instead, they are invariably confined to catchment boundaries in the absence of rare floodwaters, which has lead to genetically distinct local populations (Carini & Hughes, 2006). This makes them predisposed to declines, and makes it difficult for them to recolonise areas.

The restoration and/or protection of habitats is a great step towards increasing population sizes of species and promoting genetic diversity (more individuals means more mutations that introduce new genetic diversity), but it is contingent upon either natural recolonisation or active reintroduction. Natural recolonisation is not demanding upon our limited resources and thus is preferable, but reintroductions are often necessary and provide an opportunity to select individuals that will result in a higher genetically diverse population which increases the chances of success.

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69. The orchid with an underground following (*Rhizanthella gardneri*)

What is a plant? Well it has leaves. Then again, some plants don't have leaves, so maybe not. It photosynthesises? Well, some don't. In fact, there are all sorts of ways in which unorthodox plants defy our notion of what constitutes a plant.

The leafless and chlorophyll-less subterranean Western underground orchid (*Rhizanthella gardneri*) is one plant that defies many of them (Thorogood *et al.*, 2019). It lives underground, with only the occasional flower bract breaking the surface, making it difficult to both find and quantify its population size and structure. It indirectly parasitises the Broom honeymyrtle (*Melaleuca uncinata*) through a mycorrhizal fungal intermediary (*mycoheterotrophy*) for its energetic requirements and is pollinated underground by termites.

It was first discovered in 1928 by Corrigin farmer John Trott after ploughing, causing an international sensation, and found six more times under similar circumstances until 1959 when it disappeared. It was putatively rediscovered 300km south in 1979 at Munglinup, with new subpopulations discovered at both the original northern “site” and the new southern “site”. However, the southern population was only recently described as a new species *Rhizanthella johnstonii* (Dixon & Christenhusz, 2018), the fourth in the genus.

Four years after the discovery of *Rhizanthella gardneri*, another species of underground orchid was described as *Cryptanthemis slateri* (Eastern underground orchid) which was transferred to *Rhizanthella* in 1985 (Clements & Cribb, 1985). In 2006 a third species (as *R. johnstonii* had not been described yet) from Queensland's Lamington Plateau (within the Lamington National Park) was described (*Rhizanthella omissa*) based upon herbarium material collected in 1958 from a *Casuarina* (sheoak) forest and has been flagged as possibly extinct (Jones & Clements, 2006). A fifth species (*Rhizanthella speciosa*) was described last year, discovered by PhD student Maree Elliot in 2016 in the Barrington Tops National Park (New South Wales) by accident (Clements & Jones, 2020).

The known species of *Rhizanthella* are separated by the arid inland of Australia where they probably once have flourished before it dried out. But there is every chance that more species remain to be discovered on the western and eastern sides of the continent. Moreover, the potential for the rediscovery of *R. omissa* is also higher than for other plants given its hidden life cycle. Though even above-ground orchids can be missed, as *Corybas carsei* from New Zealand was only rediscovered by botanists in 1983 when they sat down for lunch and sat on one.

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70. An unyielding search (*Thylacinus cynocephalus*)

Most recent extinctions have been of species that still have extant congeners, that is, members in the same genus still exist. So that even if little is known about the missing species, its basic biology and ecology are unlikely to be radically different from living species such that appropriate survey methods can be developed. And if the missing species cannot be found over an appropriate time span within a representative proportion of suitable habitat it may be declared extinct.

However, for species that are monotypic at the genus level or higher (e.g. family, order etc.), and thus have a unique life history, it becomes increasingly possible that survey methods used may not be appropriate. While there is a second possible consideration here. Since the loss of a monotypic genus, family, class etc. results in a greater evolutionary loss than a congeneric one, should we enact tougher criteria that need to be met before declaring these unique taxa extinct? After all, declaring a species extinct does not ensure that it is actually extinct, but the concomitant cessation of protective measures and surveys may result in the Romeo Error (Collar, 1998).

Since the start of the 20th century we have putatively witnessed the loss of at least four taxonomic families: Chaeropodidae (pig-footed bandicoots), Lipotidae (Baiji, Yangtze River dolphin), Mohoidae (Hawaiian birds known as 'o'o) and Thylacinidae (thylacine, Tasmanian tiger). While there have been virtually no reports of living individuals of the first three families since their putative extinction, there have been hundreds and hundreds of reported sightings of the thylacine in Tasmania. And extending the geographical boundaries to Australasia as a whole, even more alleged sightings from mainland Australia have been reported, as well as a handful of second- and third-hand/anecdotal reports from New Guinea. The species was declared extinct by the IUCN (International Union for the Conservation of Nature) in 1982, and by the Australian Government in 1986, despite no thorough search of New Guinea.

While the most recent fossil of the species there dates to around 5ka, the sample size is so small that its extinction chronology cannot be established there and it may have survived much more recently. While there is no doubt that dingoes played a role in the species' extinction on mainland Australia, and New Guinea is home to wild canids, the terrain and habitat is different. Although New Guinea's Late Pleistocene hunters may also have targeted the species in addition to Cassowaries (*Casuarius* spp.) (Douglass, 2021). So, while the species is probably extinct in New Guinea too, given that the species' extinction would mean the loss of more than 30 million years of unique evolutionary history perhaps we should search longer and harder than we would for a species with surviving congeners, and longer than we have actually searched?

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71. The ghost of the river (*Scaphirhynchus suttkusi*)

For thousands of years hunter-gatherers have known that you can be sure an animal exists without having seen it yourself, as droppings, vocalisations and smells, among other signs, inform the tracker of their presence. Technology has been able to take this general principal and refine it, such as tracking devices and environmental DNA (eDNA), both of which play a critical role in the story of the Alabama sturgeon (*Scaphirhynchus suttkusi*).

Like many sturgeon species around the world, the Alabama sturgeon declined due to anthropogenic threats. There was a commercial fishery in the 1890's, while river modifications and damming (that prevents migratory spawning) further added to the problem. By the 1980's the species had declined sharply, and since 1997 only six individuals have been caught. A male caught in April 2007 was fitted with a transponder that ceased relaying information in June 2009, with the penultimate wild record being a fish seen but not collected in April of the latter year, and the last captive individual died in 2013.

It was then presumed extinct, yet without any further specimens collected or even seen we now know that it still exists. Its DNA was found in water samples in 2015 (Kuhajda & Rider, 2016), and improved eDNA sampling methods resulted in a more robust understanding of the species' movements, raising the possibility that some individuals overwinter in the Tombigbee River (Janosik *et al.*, 2021). While an even newer DNA test has allowed aging of individual fish in non-lethal ways (Mayne *et al.*, 2021).

Worldwide sturgeons are one of the most imperiled families largely due to their prized caviar, with more than half of the 27 recent species assessed as Critically Endangered by the IUCN. The Syr Darya sturgeon (*Pseudoscaphirhynchus fedtschenkoi*) was last caught in 1986 (Kamilov & Urchinov, 1995) and may be extinct. While an undescribed Middle Danube form of *Acipenser gueldenstaedtii* may also have disappeared forever (Friedrich, 2018). The Adriatic sturgeon (*Acipenser naccarii*) and Yangtze sturgeon (*Acipenser dabryanus*) are both functionally extinct in the wild with regular restocking of wild bodies of water, with the hopes of ultimately creating self-sustaining populations.

Thankfully the Dwarf sturgeon or Little Amu-Darya shovelnose (*Pseudoscaphirhynchus hermanni*) was rediscovered in 2020 (Sheraliev *et al.*, 2021), after last being recorded in April 1996 when three individuals were caught, which was itself the first record in 15 years (Birstein, 1997). Sturgeons have been proposed as a possible explanation for alleged sightings of the Loch ness monster when they rarely venture close enough to the surface to be seen. But their downturned mouths are adapted for bottom-dwelling life, and these gentle giants and dainty dwarves that can live for more than a century are harmless unless hooked or caught in a net. These ancient survivors desperately need our help.

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72. Get mummified: a shrew-d choice (*Crocidura balsamifera*)

Ancient Egypt is well known for its use of embalming techniques to achieve the mummification process, to preserve and protect the human dead in their journey to the afterlife. This practice extended to animals, particularly pets, but also to wild animals as well which offers a window into past local faunas. To date eight species of shrew (family Soricidae) have been recorded as having been mummified by ancient Egyptians (Woodman et al., 2021). For one of the species, the aptly named Mummified shrew (*Crocidura balsamifera*), this material unearthed in the early 1970's from a complex at Thebes is the only record we have of its former existence (Hutterer, 1994).

The original radiocarbon date of 2,400yrBP ± 140yr must be somewhat inaccurate due to the then absence of a calibration method to compensate for changes in atmospheric carbon over time (Reimer, 2020), but there is no doubt that the area was less arid around this time. This is partly corroborated by the placement of *C. balsamifera* within the *C. dolichura* group of forest shrews, combined with the relative rarity of *C. balsamifera* mummies (extant *C. dolichura* group species occur at relatively low densities) compared with *C. religiosa* (3 vs. 27), and suggests remnant gallery forest may have remained in the area (Hutterer, 1994). It also appears to have had a naked tail, although the rest of the body is unknown due to damage suffered unwrapping and treating the bodies, which left only a few bones (Hutterer, 1994).

The species *Crocidura religiosa* mentioned above was also known only as mummified specimens, as far back as 1827 in fact, until two living specimens were collected in the early 1900's (Woodman *et al.*, 2017). Though it has never been recorded since and so it too may be extinct, although it is listed as Data Deficient by the IUCN (Kryštufek & Kennerley, 2019). A third species of mummified shrew, Flower's shrew (*Crocidura floweri*), was considered extinct in 1962, but was later found as prey items in owl pellets (Kennerley & Saleh, 2017).

While the extinct giant Bennu heron (*Ardea bennuides*) from the United Arab Emirates has sometimes been suggested as the inspiration for the Egyptian god Bennu (Shuker, 1995). From the east of North Africa to off the western coast, the Canary Islands (named after the Presa Canario dog breed with its cat-like gait) were home to giant lizards (genus *Gallotia*) when the Ancient Egyptians were still building pyramids. The largest species (c.90cm–1m total length) was the Goliath Tenerife lizard (*Gallotia goliath*), never recorded as a living animal by science and which may have disappeared as a result of the arrival of humans but this is uncertain (Crowley *et al.*, 2019). Two naturally mummified specimens were remarkably discovered in the early 1990's which allowed the first study of the species' external morphology (Castillo *et al.*, 1994).

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73. When the dead may be alive (*Coniontis remnans*)

The term 'Lazarus taxon' has come to be used widely by the non-scientific community to refer to a species that was thought to be long extinct and known only from fossil remains but which has since been found alive. This is unfortunate because it is a misnomer, as the real Biblical Lazarus really was dead before Jesus raised him to life again. Whereas any of the many taxa rediscovered as living individuals after being described based upon fossils were alive the whole time. Therefore, a much more accurate Biblical character to base such a concept around would be Paul, who was stoned putatively to death but clearly not, thus giving us the notion of a Pauline taxon.

And while it may be safe to assume that a large-sized species based upon fossils such as a bear no longer exists, the conservation status that should be assigned to smaller species from more overlooked groups is less clear. The world famous La Brea tar pits are remarkable because they have preserved a relatively unbiased sample of invertebrates compared with taphonomically more traditional sites. One such species is the La Brea darkling beetle (*Coniontis remnans*) described from remains of Late Pleistocene age in 1954 (Pierce, 1954). Yet the genus to which it belongs has not been well studied, with many undescribed species, and it probably still survives in southern California (Miller, 1997).

Cuvier's beaked whale (*Ziphius cavirostris*) was described as a fossil species in 1823, and discovered alive in 1850. The South Island takahē (*Porphyrio hochstetteri*) was described in 1847, and discovered still living in 1850, and then famously later rediscovered in 1948. In 1846 the false killer whale (*Pseudorca crassidens*) was described based upon a fossil skull of Middle Pleistocene (781ka–126ka) age, but living animals washed ashore in 1861. The Bush dog (*Speothos venaticus*) was described in 1842 and thought to be extinct before it was synonymised with the living species.

While a range of other species have similar stories: *Adeonella adae* (bryozoan), *Alytes muletensis* (toad), *Aproteles bulma* (bat) and *Awalycaeus yanoshokoae* (a snail), just to go through the letter 'A'. And you can be sure that there will be more to come, so keep an eye out for more stories of “Lazarus taxa”. And perhaps kindly point out that the term is not very apt to describe the phenomenon. As long as the dinosaurs stay dead, we've all seen what happens in Jurassic Park...

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74. Hovering on the brink of extinction (*Hibiscadelphus woodii*)

As the hovering drone slowly scans the sheer cliff face, where no human could otherwise go, a plant comes into view. To almost anybody it would have blended into the rest of the vegetation, a rather green but otherwise unremarkable example of this part of the island's flora. Yet this was the first living example of *Hibiscadelphus woodii* seen in almost a decade, surviving only because it was inaccessible to the island's introduced species and had not been damaged or killed by rock falls. There were six known species of *Hibiscadelphus* (closely related to *Hibiscus*) before the four original plants of *H. woodii* were discovered in March 1991 and then scientifically described in 1995 (Lorence & Wagner, 1995).

At some point during or prior to 1995 a large boulder apparently crushed three of the plants and they died between 1995 and 1998. The fourth plant held on until it was found dead on 17 August 2011. Many techniques had been tried to propagate the species, a member of one of Hawaii's most endangered genera, from cuttings to grafting to air layering to cross-pollination to tip cuttings to stem cuttings, but nothing worked. While many surveys had failed to rediscovered the species, the hope was that it still existed on some inaccessible cliff (Wood, 2012). And that's exactly what the drone was able to confirm, with two other individuals found shortly afterwards, taking the total global population to a mere three plants.

Today there are eight known recent species in the genus. Beyond the rediscovered *H. woodii*, three species are believed to be globally extinct, each only known from a single wild plant that subsequently died without producing new plants: *H. bombycinus*, *H. crucibracteatus* and *H. wilderianus*. Two are functionally extinct/extinct in the wild: *H. giffardianus* and *H. hualalaiensis*. While only two species, *H. distans* and the recently discovered *H. stellatus* have wild populations of around 200 and 100 individuals, respectively.

In terms of Hawaiian plants as a whole there are around 1,400 species (c.100 of which are globally extinct), of which more than 250 have fewer than 50 plants remaining in the wild according to the Plant Extinction Prevention Program (PEPP)'s website (http://www.pepphi.org/). PEPP members are some of the most ardent conservationists in the entire world, rappelling down sheer cliffs in search of survivors to protect and conserve, propagate and reintroduce (https://www.youtube.com/watch?v=XFAQeyUfiAc&t). Tragically their funding has been cut in recent years, so if you are able to donate monetarily, please visit their website.

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75. "Am I bovid?" (*Rusingoryx atopocranion*)

Africa is our ancestral home, with countless generations of hominids spending time on the shores of Lake Turkana, as unearthed by the legendary Leakey family of anthropologists. Incidentally, an endemic bivalve mollusc (*Coelatura rothschildi*) disappeared here in the 1980's. While Lake Victoria is infamous for the cichlid cataclysm in its waters since the 1970's, though an endemic deepwater catfish (*Xenoclarias eupogon*) hasn't been seen since 1997. Within the Kenyan portion of the lake lies a small island some 10 miles long: Rusinga Island.

It is world famous for the Miocene apes (most notably *Proconsul*) uncovered there by the Leakey family. Given the long existence of humans in Africa, as well as the seeming survival of so many of its megafauna (e.g. the 'big five'), it has long been assumed that its Pleistocene fauna is basically intact. Yet this assumption is increasingly being questioned, with the discovery of a range of large-sized extinct species in recent decades (Faith, 2014), including a very peculiar alcelaphine bovid *Rusingoryx atopocranion*. Living bovids (cattle, sheep, goats, antelopes etc.) of the subfamily Alcelaphinae (i.e. alcelaphines) are grazing animals, and include the wildebeest and hartebeest, with several extinct species and subspecies present until at least the Late Pleistocene.

So although the fossilised bones of the extinct *Rusingoryx* were first found in 1983 from Rusinga Island (and now also known from Mfangano island to the south-west) (Pickford & Thomas, 1984; Tryon *et al.*, 2012), its main habitat was the Kenyan plains to the east where it munched on arid grasslands with the other members of the arid-adapted local ungulate fauna (Faith *et al.*, 2011). Its most prominent and near unique feature was an enormous nasal dome that was hollow, allowing for individuals to vocalise very loudly (O'Brien *et al.*, 2016), though under what circumstances are unknown. It may have been to impress members of the opposite sex, or been used as a threat display to rivals of the same sex, or as a warning mechanism alerting the herd of imminent danger. Given the highly evolved nature of the adaptation, it probably had several uses.

Much of the accumulation of fossil *Rusingoryx* is due to human hunting of prime animals dating to around 68,000 years ago (Jenkins *et al.*, 2017), long before the species became extinct. The latest dated specimens from both islands are of roughly the same age, around 30,000 years ago, but the sample size is far too small to infer an extinction chronology. Rather, the only well-dated extinctions of Africa's large animals (invariably grassland inhabitants) all took place later during the end of the Late Pleistocene to the early Holocene and involved sweeping changes to their grassland habitats, suggesting widespread environmental upheaval.

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76. “Duck, duck, moa-nalo” (*Chelychelynechen quassus*)

The Hawaiian Islands are arguably the best-preserved lost avifauna in the world, having lost more than 50% of its endemic birds (33 out of 64 species) since European contact. With countless more prehistorically extinct species discovered in lava tubes, caves, lake beds and middens (ancient rubbish tips) (James & Olson, 1991; Olson & James, 1991; Pérez, 2021).

Like many oceanic islands, the Hawaiian Islands lack terrestrial vertebrate predators, which allowed the evolution of stout-legged, flightless, terrestrial goose-like ducks that were the predominant herbivores until their post-Polynesian extinction. The Kaua'i turtle-jawed goose (*Chelychelynechen quassus*) was particularly notable for its turtle-like cranial adaptations, hence both its scientific and common names. While living plants armed with defensive mechanisms such as the prickly *Cyanea platyphylla* attest to their former existence. Though their coprolites (fossilised poo) suggest they preferred ferns, which they may have digested extremely efficiently (James & Burney, 1997).

DNA shows their closest relatives are the dabbling ducks (tribe Anatini), with their ancestors having split from each other around 3.6mya, making moa-nalos the earliest diverging group as none of the extant Anatini's ancestors had diverged from each other yet. In fact, the estimated divergence time between the two moa-nalo genera *Ptaiochen* and *Thambetochen* is 3.1mya, with their slow loss of flight eventually hampering their ability for inter-island travel, and thus allowing them to evolve in relative isolation from each other.

Yet there is also something of a biogeographical mystery to be solved. Maui was the only known island home to two moa-nalos, *Ptaiochen pau* and *Thambetochen chauliodous*, though Kauai may also have been (Sorenson *et al.*, 1999). But Hawaii (or Big Island) seemingly either never had a moa-nalo population or it died out for unknown reasons. Given that it is by far the largest island, and the archipelago's strict lack of predators that could predate moa-nalos, their absence is on the face of it strange.

The islands are known for their extensive island-expanding lava activity, so it might seem that Hawaii must be the most ancient of the islands given its pre-eminent size. Yet it is in fact by far the *youngest* of the main islands, having breached the surface only 500,000 years ago or long after moa-nalo are thought to have become flightless (Sorenson *et al.*, 1999).

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77. The newspaper shrew? A periodical (re)appearance (*Crocidura trichura*)

Modern political boundaries such as countries and territories can obfuscate natural biogeography. For example, the islands of Borneo, Hispaniola and New Guinea are each shared by multiple countries, political demarcations that are entirely irrelevant. So that a species being limited to one country on such an island is purely coincidental. In that vein, Christmas Island is technically an Australian territory but it is roughly 1,550km from the continent. Rather, its floral and faunal composition is more south-east Asian in origin, being c.350km from Indonesia. An excellent and enigmatic example of this is the Christmas Island shrew (*Crocidura trichura*), a member of the true shrews which never made it to Australia from Asia.

It was a common species until the late 19th century and was then last recorded prior to 1908, until two animals were uncovered while rainforest clearing was being conducted in 1958, and then two further individuals were found in separate incidents in 1985 (Schulz, 2004). One of the 1985 animals died shortly after capture, while the other lived for about a year in captivity and allowed the only two known photos of living animals to be taken. Given the tiny size of the species (4.5 to 6 grams), its underground habit, and the previous rediscovery of the species despite its squeaks not having been recorded since before 1908, it leaves open the possibility that it still exists. The likewise burrowing Christmas Island blind snake (*Ramphotyphlops exocoeti*) was also long known only from sporadic reports (the last of which coincidentally date to 1985 or 1986), and was remarkably rediscovered in 2009 (Maple *et al.*, 2012).

Christmas Island is often implicitly depicted as a paradise where humans and animals peacefully co-exist, when roads are closed and people benignly watch the world-famous red crab (*Gecarcoidea natalis*) migration that has featured in a Sir David Attenborough documentary among others. In reality, it is an extinction hotspot that has lost three of its four other terrestrial mammal species besides the missing shrew: Maclear's rat (*Rattus macleari*), Bulldog rat (*Rattus nativitatis*) and the Christmas Island pipistrelle (*Pipistrellus murrayi*) (Wyatt *et al.*, 2008; Lumsden *et al.*, 2017). The loss of the Christmas Island pipistrelle, which was last recorded on 27 August 2009, is one of the most recent of all global extinctions (Woinarski, 2018).

In the same volume, Dr. John Woinarski lists 24 endemic species of invertebrates as having not been recorded since 1902, and a further 19 species not recorded since the 1930's (Woinarski, 2018). That is a combined total of 43 endemic invertebrate species not recorded for more than 81 years, or almost a quarter of the c.200 such endemics. And things don't stop there, as one of the island's five reptile species became extinct in 2014 (*Emoia nativitatis*), two became extinct in the wild in 2012 (*Cryptoblepharus egeriae* and *Lepidodactylus listeri*), one has had to be rediscovered (*Ramphotyphlops exocoeti*), and only one remains common in the wild (*Cyrtodactylus sadleiri*) (Emery *et al.*, 2021).

On the botanical front things appear to be much better, as Ridley's jewel orchid (*Zeuxine exilis*) was rediscovered in the leaf litter of the island's rainforest in 2009, while the formerly critically endangered Christmas Island spleenwort (*Asplenium*

listeri) has proven not to be endemic to the island (Green *et al.*, 2010; Ohlsen *et al.*, 2015).

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78. The Dinosaur ant (*Nothomyrmecia macrops*)

Many dinosaur fossils have been found in Australia's outback, most notably around Winton in Queensland, which is the only known place in the entire world where the tracks from a dinosaur stampede can be seen. Winton is also where Banjo Patterson wrote the lyrics to Australia's unofficial anthem Waltzing Matilda. Yet while Australia's polar dinosaurs, subjected to long periods of darkness annually, have been extinct for many millions of years (Rich and Vickers-Rich, 2000), a living dinosaur of sorts still stomps around.

As eusocial insects, ants hold a special place among evolutionary biologists for their über altruistic behaviour that *prima facie* runs counter to natural selection (Cronin, 1991), so the discovery of the Dinosaur ant (*Nothomyrmecia macrops*) in the early 1930's permeated the myrmecological world, with the species' immediate disappearance for more than four decades only adding to the importance of finding more living individuals. Ants evolved from wasps, which given their different social structures means that there was an origination and evolution of ant colony dynamics which a species of ant that is basal (much closer to the wasp ancestor, hopefully retaining "primitive" traits) could help to elucidate. And the Dinosaur ant was just such a key species ripe for the study of ant evolution, the most primitive living species of ant known then or now.

It was originally known from two individuals collected in 1931 from near the Russell Range in the south of Western Australia, though there is some uncertainty about this locality, especially since the species appears never to have been recorded from the state again. These were recognised as a new genus by entomologist John Clark (Clark, 1934), but with no new records of the species active searches were conducted for it (e.g. Brown & Wilson, 1959). Its eventual rediscovery at Poochera in South Australia in October 1977 made global headlines (Taylor, 1978) and led to numerous studies of this remarkable species.

It lives in colonies of 50-100 individuals, which is considerably smaller than many species. And the workers, which all look the same, hunt individually at night rather than co-operatively. While its secretory glands have also been intensively studied (e.g. Billen, 1990). To most people ants are a mild amusement during childhood, and an inconvenience for home owners particularly during winter when they attempt to seek shelter inside homes. While the nominal resemblance of the timber-eating 'white ants', actually the sole closest relatives of cockroaches (collectively comprising the order Blattodea) and thus not true ants or even close relatives, further bring down their reputation.

Invertebrates of all kinds are deserving of study, whether they represent otherwise unknown primitive states like *Nothomyrmecia macrops*, or display highly derived traits of their 'modern' counterparts.

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79. Lost thrice, lost forever (*Nesiota elliptica*)

For us money is not a golden ticket to happiness, and for other species rediscovery is not a golden ticket to survival. St. Helena in the Atlantic Ocean west of Africa is an extinction hotspot, exacerbated by its high level of endemicity, such as the world's largest earwig (*Labidura herculeana*) aptly named the Giant earwig and the Giant ground beetle (*Aplothorax burchelli*) both last seen in 1967. A decade later false hope arose as the St. Helena olive (*Nesiota elliptica*), only superficially resembling the oily fruit's leaves much like Australia's *Grevillea olivacea*, was rediscovered.

The only known stronghold of the species for two centuries was the Diana's Peak area, with its pre-human distribution largely unknown and now lost, before it disappeared forever or so it was thought. In 1977 George Benjamin rediscovered a single individual, with no further wild plants ever found. Four seedlings and one cutting survived in cultivation, taken from this plant at a prior date, when the death of the last wild plant was announced on the local radio station on 4 October 1994 (http://sainthelenaisland.info/rshnews19941014deathofsthelenaolive.mp3). The last of these saplings died in December 2003 from a fungal infection, rendering not only the species but also the genus globally extinct (Lambdon & Ellick, 2016). To this day the occasional root mass is dislodged from loosened soil in a demonstration that the now extinct species, like virtually every other, had a healthy and thriving population before humans arrived.

It might seem then that even more extreme measures were going to be needed to ensure the survival of one of St. Helena's plants, when one man literally put his life on the line to save a species. Just three years after rediscovering the St. Helena olive (*Nesiota elliptica*), George Benjamin spotted two curious plants growing on the side of a sheer cliff in 1980 while having tea with a young Quentin Cronk (now a world authority on the island's plants) on the latter's two-week visit to the island. His brother Charlie Benjamin was tasked with retrieving pieces of it for examination, and with only a few wooden stakes, a thin main line and a safety line tied around him, nothing like today's safety equipment standards employed in the Hawaiian Islands (see No. 74), he dangled hundreds of feet above the treacherous rocks and ocean and took several cuttings including a flower and seed pod.

Only after he was back on solid ground and the plant was confirmed as the long lost (since c.1850) ebony (*Trochetiopsis ebenus*) did Charlie have a brandy! Three years later he made the same extremely perilous journey to retrieve cuttings from the second plant to increase the genetic diversity of the cultivated population, but declined a third invitation to get soil samples for fear of the effects on his wife knowing what he would be risking.

Today many St. Helena gardens have a flowering ebony in them, an indirect gift from the Benjamin brothers. And it has recently become the island's official flower, a symbol of hope if ever there was one. There are two other recent species in the genus, *Trochetiopsis erythroxylon* which is extinct in the wild, and *Trochetiopsis melanoxylon* which was last recorded in 1771 and is considered globally extinct. Like many islands around the world, St. Helena is a botanical black hole where plants disappear forever (Magdalena, 2018).

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80. A faint idea of what we've lost: a goat-reptile hybrid? (*Myotragus balearicus*)

Social media, like many things in this day and age, is a double-edged sword. As I pointed out in the Preface, it has greatly helped to bring attention to many lesser-known plants, animals and fungi. It has also expressed a fondness for fainting goats which fall over when startled. Technically known as the Myotonic Tennessee Fainting goat, the breed appears to have been rediscovered in the 1980's and suffers from a heritable genetic condition called *myotonia congenita* which affects the muscles' ability to relax after involuntary movements. Yet as novel as this breed is, a wild cousin of it's was truly bizarre, more akin to a reptile than a goat in some respects.

The Balearic Islands cave goat (*Myotragus balearicus*) was endemic to the four Balearic Islands (Cabrera, Dragonera, Mallorca & Menorca) in the western Mediterranean, and is last recorded around 2800–2400BCE not long before humans arrived on the island which are assumed to be the species' cause of extinction (Bover *et al.*, 2016). Its unique adaptations to the low-energy environments of the four islands, especially being slow-moving (Bover *et al.*, 2005), made it extremely vulnerable. It had forward-facing eyes, and reduced brain size and sense organ size largely mirroring the domestication process. In this case due to the lack of a need for such sophisticated sensory data in the absence of predators and their energetically costly nature (Köhler & Moyà-Solà, 2004).

While the study of coprolites (fossilised faeces) has shown that the main part of its diet was constituted of a species of boxwood (*Buxus balearica*), which it digested very efficiently to extract as much energy from the vegetation as possible (Alcover *et al.*, 1999). Yet its most extreme adaptation was its variable bone growth that ceased periodically in response to resource limitations, patterns of growth otherwise unknown in a mammal and only known from ectothermic reptiles (Köhler & Moyà-Solà, 2009). Its metabolism was seemingly synchronised with the contemporary resource levels at any given time which allowed it to eke out an existence in such an energy-poor environment.

Of course, this kind of strategy may have been more widespread on other Mediterranean islands (Köhler & Moyà-Solà, 2009) but for the lack of such exquisitely preserved specimens as we have of *Myotragus* that allows us to study such details of its life history. But as strange as the genus is, whether truly unique among (Mediterranean) mammals or not, it split from an extant species at some point in the past. The most recent and thorough DNA analysis concluded that its ancestor split from the ancestor of the Himalayan takin (*Budorcas taxicolor*) around 7.1mya (Bover *et al.*, 2019).

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81. A ray of hope, or an overlooked species? (*Gymnura tentaculata*)

The pressure on scientists to publish or perish as a misguided metric of their worth imposed from on high is slowly transforming into "publish and perish" as the scientific literature grows and grows and makes it more difficult for authors to have their work read by more than a few people. I have had my suspicions for some years that this was affecting the integrity of papers reporting the rediscovery of one or more taxa. Though the absence of a definitive and widely agree definition of 'rediscovery' lead me to be somewhat cautious.

For example, while there is no doubt that anthropogenic threats permeate even the deepest depths of our oceans (Chiba et al., 2018), the reported rediscoveries of several deep-sea species seemed questionable to me (e.g. Komai *et al.*, 2017; Gong *et al.*, 2020), since those depths are both extremely vast and rarely explored. But all of this was confirmed with the latest and most egregious example yet, that of the Tentacled butterfly ray (*Gymnura tentaculata*). To be clear, the species was listed as possibly extinct by the IUCN's Shark Specialist Group (Jabado *et al.*, 2017), but so was the Pondicherry shark (*Carcharhinus hemiodon*) which had in fact been reported several times since the alleged last record in 1979 (https://shorturl.at/ahqIJ).

A 2009 RedList assessment of the species treated the Tentacled butterfly ray as Data Deficient due to its habitat and ecology being virtually unknown (Jacobsen, 2009). It was considered to probably be endemic to Indian waters as specimens from Papua New Guinea were likely misidentifications, omitting any records from Pakistan and thus contradicting the later assessment by (Jabado *et al.*, 2017).

Given that many sharks and rays are little studied, which may surprise readers given their impact on our perceptions of the ocean, this geographical distribution should have been considered tentative. This is further supported by the fact that the alleged rediscovery involved the finding that the species constitutes fully 15% of ray by-catch on the Iranian trawlers surveyed. Clearly then the species was simply overlooked, and while it has disappeared from much of its historical range, a more appropriate categorisation of the finding would have been as a range extension.

To be sure, marine biologists cannot be on every single fishing vessel in the world at every moment, so they can quite easily be forgiven for not having known that there was a healthy Iranian population. But at the same time, reporting the rediscovery of a species that is relatively common outside of its claimed historical range potentially negatively affects the public perception of the competence of conservationists.

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82. A dark flight to extinction (*Trisyntopa* sp.)

The Australian outback is a notoriously dry and unforgiving environment that has claimed many human lives over the last few centuries of European colonisation, from aboriginal inhabitants to early explorers to modern travellers.

In 1977, two of the last nomadic Aboriginal people in Australia, Warri and Yatungka of the Mandildjara tribe of the Gibson Desert, were rescued from the century's worst drought (Peasely, 1983). They had eloped in the 1930's as their marriage was against tribal law, but their Mandildjara elders (including Mudjon) were still concerned for their wellbeing despite their transgression, and had tried to find them over the decades. When they were eventually found they were by then elderly and emaciated, with Warri carrying a debilitating leg injury that prevented him from hunting: his wife Yatungka was keeping them both alive. Daily descending metres to a dirty water source to quench their thirst and that of the dingoes that helped Yatungka hunt and keep them both warm during the cold nights.

Given the choice to stay and die as true nomads or be the last of their people to leave their cultural land, they were forced to abandon their traditional way of life. Leaving thousands of square kilometres without Aboriginal inhabitants for the first time in literally thousands and thousands of years. They died less than a month apart in 1979 after she refused to eat following his death, and are buried next to each other in the Wiluna Cemetery (with Mudjon) to be together for eternity.

Another victim of the outback was the Paradise parrot (*Psephotellus pulcherrimus*), the most beautiful bird in the world by the reckoning of some. A winged rainbow that seemed so out of place: a delicate looking bird in a brutally harsh environment. Dr. Penny Olsen's book *Glimpses of Paradise* about the species is one of the greatest natural history books aimed at the general reader, and evokes a sense of loss like few authors can (Olsen, 2007).

She also briefly discusses the likely loss of a symbiotic species of moth of the genus *Trisyntopa* that hypothetically inhabited the termite nests of the Paradise parrot (Edwards *et al.*, 2007; Olsen, 2007). There are two other members of the genus *Psephotellus* that nest in termite mounds, the Hooded parrot (*Psephotellus dissimilis*) and the Golden-shouldered parrot (*Psephotellus chrysoptergius*), both of which co-habitate with a unique species of *Trisyntopa* moth. Rendering it likely that the Paradise parrot was likewise associated with a unique moth that benefitted from the parrot excavating cavities for its nesting and by using the parrots' faeces as food for the offspring.

Visiting known and potential former termite nests of the Paradise parrot may uncover remains of this moth whose former existence is implied by analogy.

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83. A shell of its former self (*Nesiocina mangarevae*)

When malacologist Philippe Bouchet spent ten days on the Gambier Islands in September 1997 he was met with by the carcasses of tens of thousands of animals. They were snails that were long extinct (100+ years ago) yet many had not been described as new species yet; hidden in plain sight among the soil and leaf litter. Many were representatives of a new genus in the family Helicinidae, *Nesiocina* ('nesios' is Greek for 'island').

Only millimetres across, and thus very easy to overlook among the leaves and dirt, with unique growths near their shell opening that may have served as protection against native predators (Richling & Bouchet, 2013). Traits that were ultimately helpless against the dual colonisations of Polynesians and Europeans, seemingly succumbing to anthropogenic extinction decades before the spread of the Rosy wolfsnail (*Euglandina rosea*) that would result in the loss of hundreds more snail species in the Pacific region (Clarke *et al.*, 1984; Coote & Loeve, 2003; Régnier *et al.*, 2009; Cowie *et al.*, 2017). Today only a single living species of this helicinid (family Helicinidae) radiation, *Sturanya makaroaensis*, still exists in the Gambier Islands.

Bouchet collected more than 50,000 shells of both native and introduced species, supplementing the earlier and smaller 1934 malacological expedition to the islands, which collectively tell a straight forward tale of mass extinction (Bouchet, 1998). On Aukena he found two extinct species of the new eponymous genus *Aukena* of euconulid (family Euconulidae) snails, with only a single living species of the family, *Philonesia mangarevae*, surviving on nearby Mangareva (Bouchet & Abdou, 2001).

While both species of the family Assimineidae that inhabited the islands, *Cyclomorpha secessa* and *Omphalotropis margarita*, are now extinct (Bouchet & Abdou, 2003). The fourth snail family from the islands, Punctidae, is represented by a single species (*Punctum mokotoense*) known from recent shells and is thought to still survive in the sole remnant patch of forest on Mangareva (Abdou & Bouchet, 2000).

But the biggest loss was the family Endodontidae, which lost all 30 species known to have been present on the islands (Abdou & Bouchet, 2000). Altogether, 46 species are known from the Gambier Islands, of which only three are believed to survive, an extinction rate of 93.5%. The only possible silver lining to this is that their hard shells make their former existence and diversity well known, and so there are probably very few if any species that went extinct without us having any retrospective record of them.

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84. Three kings in one (*Pennantia baylisiana*)

The Aupouri Peninsula is the northern point of New Zealand's North Island which juts out into a vast empty ocean. Cape Reinga is the westernmost portion and it was here that the Cape Reinga white rātā or Bartlett's rātā (*Metrosideros bartlettii*) was only discovered in 1975 despite reaching up to 30 metres (Dawson, 1985). The profusion of white flowers gives the appearance of an alpine environment, looking like a snow-covered plant. Unfortunately, it is critically endangered with only 13 adult trees alive in the wild in 2015, being faced with multiple threats that have reduced the known population from a high of 34 trees in 1992 (de Lange, 2021a). Yet by comparison to the next two plants, it is widespread.

Some dozen kilometres north of mainland New Zealand lie the Three Kings Islands (Manawatāwhi), a tiny speck on any map you're lucky enough to find them on. A young botanist, Geoff Baylis, conducted a botanical expedition there in late 1945 just prior to the destruction of the introduced goats to ascertain its status (Baylis, 1948). He would discover two new plant species, each represented by a single individual with no other individuals of either species found since. The lesser known of these is the Three Kings vine (*Tecomanthe speciosa*) which still persists to this day, though the removal of the goats had the deleterious effect of shading the plant preventing it from fully blooming since 1946 (de Lange, 2021b).

The far more famous Three Kings Kaikōmako (*Pennantia baylisiana*) initially deceived Baylis who thought it was a specimen of the karaka (*Corynocarpus laevigatus*), but it soon became clear that it was something unique. It was shortly described as a new species honouring Baylis as the discoverer, though with only a single specimen ever found its taxonomic status has been the subject of much discussion over the years (e.g. Gardner & de Lange, 2002). Unlike most trees it has the unusual habit of having a multi-stemmed trunk further exacerbated by the many suckers that may be recruited as true trunks in older plants, and would have been a mixed population of females and males (*dioecious*) prior to reduction to a single individual.

It was therefore thought that viable seed was a thing of the past for this species, but in recent decades both the original wild plant and cultivated progenies have produced viable seed (Gardner & de Lange, 2002). All three of the above plants are being grown in cultivation, not only to serve as an insurance population against the extremely real threat of extinction, but also to marvel at these plants that could easily have already disappeared without any record of what they even look like.

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85. "I'll be back" (*Capra pyrenaica pyrenaica*)

Any species that disappears as a result of anthropogenic extinction is arguably unlucky on top of everything else because it could theoretically have existed during a different geological period when there were no humans. But one loss in particular is acutely unfortunate, while raising the ambivalent notion of conservation cloning. The term 'endling' has come to be popularised as a pithy phrase for the very last individual of a species or subspecies, and with the continuing biodiversity crisis quite a number of them have been held in captivity at their death (e.g. Nicholls, 2006; Woinarski *et al.*, 2017; González *et al.*, 2020).

On the other hand, Celia, the last known Pyrenean ibex (*Capra pyrenaica pyrenaica*), was allowed to roam somewhat free, with DNA samples taken while she was still alive in the hopes of later resurrecting the species. On 6 January 2000 barely six days into the new millennium she died, not from old age or loneliness but from a falling tree that all too painfully mirrored the fall of her subspecies' branch from the tree of life due to trophy hunting and epizootic disease transmitted from livestock (Forcina *et al.*, 2021). Then on 30 July 2003 a single clone of Celia was born, but unfortunately died after several minutes due to lung defects (Folch *et al.*, 2009), the world's first true Lazarus taxon (see No. 73).

This contributed greatly to the perennial discussion around conservation cloning and related methods to achieve what has become known as de-extinction (Shapiro, 2017); its advantages and drawbacks, the ethical considerations, the metaphysical views, and even legal implications and patentability (e.g. Piña-Aguilar *et al.*, 2009; García-González & Margalida, 2014). With a series of high-profile candidate taxa for resurrection now widely disseminated: the Woolly mammoth (*Mammuthus primigenius*), the dodo (*Raphus cucullatus*), the Passenger pigeon (*Ectopistes migratorius*), the thylacine (*Thylacinus cynocephalus*), the Southern gastric brooding frog (*Rheobatrachus silus*), even Neanderthals (*Homo neanderthalensis*).

Beyond Celia, the closest any other species has come to being truly resurrected for even a few brief moments are embryos of the Southern gastric brooding frog (*Rheobatrachus silus*) which were grown in a donor frog before they ceased dividing (Phillips, 2013). In time there is little doubt that other species and subspecies will follow in Celia's footsteps, substituting in the appropriate form of locomotion.

But as much I wish to see a mammoth, and long for the day that I might lock eyes with one, it is ultimately close to a red herring. The real problem of the current biodiversity crisis does not have such a simple solution. It will take large-scale changes to our society to live more in harmony with the world around us and shift as far as possible towards renewable sources. After all, very few are talking about bringing plants and fungi back to life (Rocchetti *et al.*, 2021; Wolkis *et al.*, 2021) beyond their smell (see No. 10). Won't somebody please think of the plants?

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86. Snaking its way out of extinction (*Aipysurus foliosquama*)

Before several high-profile cases of putative extinction due to climate change since the new millennium (see No.'s 7, 25 and 64), there were a series of marine species which disappeared as a result of, or in the aftermath of, the historically worst recorded El Niño–Southern Oscillation (ENSO) event in 1982–1983 that hit the Galápagos Islands of Ecuador the hardest but affected South America more generally too. The Galápagos damselfish (*Azurina eupalama*), Galápagos stringweed (*Bifurcaria galapagensis*) and 24-rayed sunstar (*Heliaster solaris*) have all not been recorded since (Miller *et al.*, 2007; Allen *et al.*, 2010; Edgar *et al.*, 2010).

Wellington's solitary coral (*Rhizopsammia wellingtoni*) was reduced to two colonies, and has not been recorded since 2000 (Hickman *et al.*, 2007). While Boschmai's fire coral (*Millepora boschmai*) of Panama initially disappeared causing it to be considered possibly extinct when it was later described (De Weerdt & Glynn, 1991), but was subsequently found again before disappearing a second time, but has been reported from Indonesia pending taxonomic confirmation (Guzmán & Edgar, 2008). This can be contrasted with the mysterious decline of the sea snakes of Ashmore and Hibernia Reefs, part of the Territory of Ashmore and Cartier Islands that lies at the extremity of the Continental shelf 320km north of mainland Australia.

As recently as 1994 Ashmore reef was home to at least 9 different species of sea snakes (with 5 others recorded as vagrants to the area), but by 2002 there were only five recorded species, and by 2005 only two of these species were regularly recorded (Lukoschek *et al.*, 2013). In 11 years, the reefs went from a biodiversity hotspot to an extinction hot spot, but why nobody is quite sure, though changing efficacy of survey methods has been ruled out. Hypothesised threats include habitat degradation, climate change and disease, but as the reefs are so remote they are rarely visited by scientists and have actively been protected, exacerbating the mystery (Lukoschek *et al.*, 2013).

Thankfully, in contrast to the 1982–1983 ENSO event most of the fourteen (or seventeen plus) sea snakes historically recorded from the reefs were not endemic and thus constitute local extinctions, and the two species that were endemic have been rediscovered. The Short-nosed sea snake (*Aipysurus apraefrontalis*) was last recorded in 1998 or 2000 (accounts vary), but was the third local species to be rediscovered at a much greater depth than previously reported raising yet more questions (Kilvert, 2021). While the Leaf-scaled sea snake (*Aipysurus foliosquama*) was rediscovered in 2010 after a specimen washed up on Barrow Island well outside its historically reported range (Lukoschek *et al.*, 2013).

A global assessment of the world's sea snakes has found that one-third of them are too data deficient to assign a conservation category (Elfes *et al.*, 2013).

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87. Lake Lanao: The Lake Victoria of the East (*Barbodes* sp.)

The destruction of East Africa's cichlid species in Lake Victoria since the 1970's, due to the introduction of the Nile perch (*Lates niloticus*) in the 1950's, is one of the great (terrible) tragedies of the 20th century (Goldschmidt, 1996; Harrison & Stiassny, 1999). The centrepiece of anthropic destruction that made the 20th century the bloodiest of all time for biodiversity loss. Some 100–150 species likely went extinct as a result, although the vast murky water leaves open the possibility that some (or many) of these may in fact have survived. Which includes the overshadowed Lake Victoria deepwater catfish (*Xenoclarias eupogon*). On the other side of the planet, a smaller version of this ichthyological annihilation has taken place in Lake Lanao on the Philippine island of Mindanao.

By comparison to the gigantic Lake Victoria at 59,947 km^2 (23,146 sq mi), Lake Lanao covers a relatively small 340 km^2 (131.275 sq mi). Which belies the fact that it was formerly home to a radiation of 17 endemic species of cyprinid (carp family) fishes in the genus *Barbodes*. But 1964 is the last time six of those were ever recorded, while a further seven were last recorded between 1973–1977. Meaning 13 species disappeared in thirteen years (1964–1977). A fourteenth species (*B. amarus*) held on a little longer (1982), and a fifteenth (*B. baoulan*) longer still (1991). All have now been declared extinct by the IUCN's RedList of threatened species. Of the two remaining species that made it past the year 2000 (*B. sirang* and *B. lindog*), they were last recorded in 2007 and 2008 respectively, and have been listed as possibly extinct. All seventeen endemics are probably gone forever.

Two further species of *Barbodes*, one nearly endemic (or endemic) to Lake Lanao but also occurring in surrounding waterways (*B. tumba*), and one widespread but probably introduced (*B. binotatus*), both survive in the lake. The usual suspects in freshwater extinctions, pollution, overfishing, and introduced species, are to blame. While more recent reports of algal blooms hint at the deeper trouble that the lake, still home to other aquatic-associated species such as waterfowl, as well as at least 11 introduced fish species, is in.

Given that both of the two non-endemic *Barbodes* species still survive while all of the endemic species went extinct, it strongly suggests (though doesn't prove) that the latter were more susceptible to extinction. It must also be pointed out that the last records for the various species, while likely reflecting their differential susceptibility (i.e. some were able to hold on much longer), also reflects the sporadic scientific collecting that has taken place, as opposed to the continual fishing by residents (Ismail et al., 2014:428).

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88. Extinction is a burning problem (*Phalanger matanim*)

Australia's 2019–2020 bushfire season was one of the world's historically worst, making global news and prompting an outpouring of support and donations. It also raised to the fore the threat that bushfires pose, not just to individual animals (which is bad enough), but also to entire species.

On Kangaroo Island off the southern coast of South Australia more than half of the island (200,000ha or 494,210 acres) was devastated (Martin, 2020), including 96% of the world-famous Flinders Chase National Park, leaving two people dead and countless native species clinging to life. Indeed, at least two endemic species, the Kangaroo Island dunnart (*Sminthopsis aitkeni*) and Pelican spider (*Zephyrarchaea austini*), were feared (functionally) extinct in the aftermath. Amazingly, both species have since been recorded in the wild and hope remains that their populations can bounce back (McMahon, 2020; Kilvert, 2021).

More than two decades earlier, on the island of New Guinea off the northern coast of Australia, a fatal tragedy took place. The eponymous Telefomin cuscus (*Phalanger matanim*), endemic to the Telefomin and Tifalmin areas in West Sepik Province, was described by world famous mammologist Tim Flannery in 1987 (Flannery, 1987). A further three specimens were collected over the next decade, while a fourth specimen was seen in 1997 (Leary *et al.*, 2016). This would be the last record of the species, with a huge bushfire burning almost all of its known habitat the next year (1998), exacerbated by the species' slow-moving habit meaning there was little chance of escape. Surveys since then have failed to record the species, though some hope remains that it may have a broader distribution than previously thought (Leary *et al.*, 2016).

On mainland Greece, the Peloponnesus peninsula was home to the Three-lobed bush-cricket (*Rhacocleis trilobata*), described in 1974 from a few specimens collected the previous year (La Greca & Messina, 1974). With a known extent of occurrence of only 25km^2, it has not been seen again and bushfires are the suspected causes of its disappearance (Willemse *et al.*, 2016). But not all species are negatively affected by fires, with many plants here in Australia being fire-adapted (*pyrophytes* and *fire ephemerals*).

In a tragic irony, there are some animals that may naturally benefit from fire in a healthy ecosystem, which transforms into a death sentence when the habitat degrades. On South Africa's Table Mountains, the Scarce mountain copper (*Trimenia malagrida malagrida*) may once have benefitted from the infrequent fires every decade or so, but more recently they turned fatal with their increased occurrence and the subspecies has not been seen since 1994 (Claassens, 2006).

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89. The tree that dwarfs giants (*Eucalyptus regnans*)

When the ancestors of Australia's aboriginal people entered the continent roughly 50–70,000 years ago, they were met with by a climate that would become much drier over the millennia. Yet the same landmass was also home to lush rainforests, grasslands, alps, swamps and woodlands. As these family groups moved across the land, they would have encountered many things unknown to them. One can only imagine the shock on the faces of that first group to see a giant Mountain ash (*Eucalyptus regnans*) before 19th century woodcutters chopped down the largest of them.

The very largest individuals soared to 152.4 metres (500 feet) or more (Ferguson, 1872), though the reason they grow to such great heights remains something of a mystery. With growth rates of up to 2 metres per year, and fires a constant yearly threat, competition for sunlight is an obvious and plausible suggestion. Though it may very well not be the full story. But whatever the reason, they are a vital part of the local ecosystem, providing an enormous swathe of canopy for all manner of species, and nest hollows for the rediscovered Leadbeater's possum (*Gymnobelideus leadbeateri*).

Australia's gum trees also dominate the continent by area like no other. Yet despite their instant familiarity, their diversity is still being discovered. Every year new species of eucalypt are described, mainly from the arid inland which is less often visited by botanists for logistical reasons. *Eucalyptus recurva*, the Ice Age gum tree or Mongarlowe mallee, was only discovered in the 1980's and the oldest one could be 13,000 years old (Crisp, 1989; NSW NPWS, 2003).

Given the vast swathes of land which have been cleared for agriculture, many species have suffered severe range contractions (Fensham *et al.*, 2020). While three species, *Eucalyptus nutans* (Red-flowered moort), *E. rameliana* (Ramel's mallee, Giles' mallee) and *E. steedmannii* (Steedman's gum, Steedman's mallet), have had to be rediscovered (Crisp, 1989; Hopper, 1992; McQuoid & Hopper, 2007).

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90. Plagued by doubt (*Mitu mitu*)

There are some species (mainly plants) that have been rediscovered after multiple centuries, such as the Cahow or Bermuda petrel (*Pterodroma cahow*) rediscovered after roughly 330 years (Murphy & Mowbray, 1951). And *Artemisia insipida* from the daisy family, rediscovered after 223 years (Garraud & Gigot, 2011). Most of these are spread around the world, and often result from confusion over identity rather than actually disappearing for centuries.

The German naturalist George Marcgrave died in 1644, before his contribution to Willem Piso's book *Historia Naturalis Brasiliae* (1648) could be published. In it Marcgrave described two Atlantic Brazilian species, a capuchin monkey and a curassow (galliform bird), that each subsequently disappeared for centuries before their rediscovery.

The Blond capuchin was last recorded in 1774, before being rediscovered in 2006 after 232 years (de Oliveira & Langguth, 2006), its identity previously uncertain due to the lack of specimens. Although listed as endangered by the IUCN (Valença-Montenegro et al., 2021), it lives in very large groups of up to 150 and is not in immediate danger of extinction.

On the other hand, the Alagoas curassow (*Mitu mitu*) was immediately forgotten after 1648, confused with the widespread Razor-billed curassow (*M. tuberosum*), until a female bird was captured in 1951 after 303 years (Pinto, 1952). If ever a rediscovery occurred in time to save the species, it was this one. Its home in the eastern Brazilian Atlantic Forest was rapidly being cut down to make way for sugarcane plantations, exacerbating the hunting pressure it was already facing.

Most of the wild population was rounded up in 1977 and brought into captivity, where it has slowly been increasing, although hybridisation with the Razor-billed curassow with which it was long confused means only around two-thirds of birds are pure bred. The remaining wild birds were killed by hunters in the 1980's and its original forest home has now largely disappeared. Reintroduction attempts are being made (Francisco *et al.*, 2021), but even with a captive insurance population, its future is extremely tenuous.

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91. Primitive notions of a snake (*Wonambi naracoortensis*)

The term “primitive” when referring to an organism is potentially misleading. It does not refer to a species that is a relic of a bygone era, a novelty that will sooner or later go extinct in the face of superior species. Rather, it refers to a species that retains a relatively high proportion of ancestral or less derived traits, which although often giving it a “simpler” or “archaic” look, is belied by the fact that it has survived until the present (evidence of its well-adaptedness to present conditions!).

The latest known surviving member of the now extinct basal snake family Madtsoiidae was *Wonambi naracoortensis* (Smith, 1976), named after the world-famous Naracoorte Caves in South Australia (home to innumerable bones from Australia’s extinct megafauna), survived until the Late Pleistocene (126ka–11.7ka) and was likely 5–6m long. Although it is the only recorded species from the Pliocene as well (5.333–2.58mya), making it currently by far the longest known surviving member of the group.

The youngest Australian madtsoiid snake genus besides *Wonambi* (including the older species, *W. barriei*) was *Yurlunggur* (named after the Rainbow Serpent of the Dreamtime), with a single species *Y. camfieldensis* described to date (Scanlon, 1992). It is believed to have been semifossorial and mesic-adapted (5–6m in length), and likely became extinct during the mid-Miocene or soon after as the continent cooled and dried (Palci *et al.*, 2018).

While the arid-adapted *Wonambi* was better suited to the changing conditions, only going extinct much later as the continent dried even more and many of its prey species disappeared. Nothing to do with its basal nature as a relatively primitive species. In 1977, one year after the original description of the extinct *Wonambi*, another Australian snake was described, the 4–5m living Oenpelli python (*Nyctophilopython oenpelliensis*) from Arnhem Land in the Top End (Gow, 1977). It remains little known today despite its large size, although the tiny captive population has allowed some insights into its biology and ecology.

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92. A real life monster (*Cooloola propator*)

The insect order Orthoptera contains the crickets, grasshoppers, locusts and katydids, as well as more unusual species such as the sandgroper, plus the enormous wētā's of New Zealand (which are *polyphyletic*). In 1980, a truly bizarre species unlike any other orthopteran was described from Cooloola National Park in Queensland, Australia, dubbed the Cooloola monster (*Cooloola propator*) and placed in a new family, Cooloolidae (Rentz, 1980).

The specimen was caught in a pitfall trap in 1976, and was initially taken by David C. Rentz (to whom it was later sent) to be an amusing joke to usher in his new appointment as Curator of Orthoptera at the CSIRO's National Insect Collection in Canberra. On the contrary, he quickly realised its legitimacy, and a publicity campaign was run to try to uncover more specimens. Over the next year, despite great personal exertion by Rentz in trying to find further specimens for himself, he was sent several that had all been collected serendipitously by a diverse range of people. One specimen had been collected on Fraser Island off the Queensland coast.

Over the next 20-odd years a further three species were discovered, all from Queensland, all by accident, and all described by Rentz (Rentz, 1986; Rentz, 1999). They are largely subterranean in habit which is why they are so elusive, although the lighter-bodied males will emerge after heavy rainfall. Beyond one of the original specimens of the Cooloola monster (C*. propator*) being found on Fraser Island, the last species discovered to date, Pearson's monster (*C. pearsoni*), inhabits South Percy Island (Rentz, 1999). Given their underground habit, particularly the bulkier females which invariably never come to the surface, the existence of the genus on islands off the coast of Queensland independently implies their former connection to the mainland before rising sea levels cut them off.

Given the serendipitous discovery of most specimens of the genus to date, it is remarkable that Eungella National Park ranger Steve Pearson was the discoverer of two of the species. The Dingo monster (*C. dingo*) from Dingo, Queensland, and the eponymous Pearson's monster (*C. pearsoni*) from South Percy Island. By coincidence, all three of these locations are important sites in the story of Australia's extinct and rediscovered animals.

Eungella was the region of disappearance of the endemic Northern gastric brooding frog (*Rheobatrachus vitellinus*) and Eungella day frog (*Taudactylus eungellensis*), with the latter since rediscovered (Meyer *et al.*, 2020). Dingo was the site of the rediscovery of the Bridled nail-tail wallaby (*Onychogalea fraenata*) by fencing contractor Mr. D. Challacombe in 1973 (Gordon & Lawrie, 1980). While the Percy Islands are the collection locality of Australia's second most mysterious bat, the Dusky flying-fox or Percy Islands flying-fox (*Pteropus brunneus*) known from a single specimen collected in 1859 or 1874, and reports of flying individuals from the 1890's (Tsang, 2020).

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93. A true behe-moth (*Aoraia mairi*)

Larger species tend to be more extinction prone due to traits associated with their increased size: fewer offspring, slower reproduction rate, greater energy needs etc. And they also tend to be the quickest to be rediscovered as they are easier to spot. Although that is a broad generalisation as any animal at low enough densities can be extremely difficult to find. New Zealand's largest moth, the beautiful green puriri moth (*Aenetus virescens*) spends up to six years as a caterpillar and then just two days as a moth with a wingspan up to 15cm.

It is only rivalled by the almost mythical Buller's moth (*Aoraia mairi*) at 14.45 cm (5.6875 in), known from a single specimen collected by Walter Buller from the Ruahine Range of the North Island in 1867 (Buller, 1872). With a brown body and overall darker appearance, there is no confusing the two species, yet one of them has only ever been met with on a singular occasion as far as anyone knows. And although sent to the British Museum, the specimen cannot now be traced.

Unlike the Frosted phoenix (see No. 4), there is every chance that a member of the public would recognise this moth, assuming that it still exists at the wooded summit. Or if it is extinct, why it became extinct is unknown. Though inferring extinction from a single specimen is fraught with difficulties (Roberts & Jarić, 2020). And even when three specimens exist in the case of another New Zealand moth, *Stigmella maoriella* (last record: pre-1854), its status is often indeterminate (Donner & Wilkinson, 1989).

The most recent New Zealand moth to disappear is *Xanthorhoe bulbulata*, last recorded between 20 February and 14 March 1991 (Patrick, 2000). Thankfully, it isn't all bad news for their moths. The Kauri leafminer (*Parectopa leucocyma*) was rediscovered in 1958 (Wise, 1962), *Agrotis ceropachoides* was rediscovered on 4 July 2012 after more than 100 years (Patrick, 2014), and the recently described *Sabulopteryx botanica* was long known only from a larval specimen on an herbarium sheet (Hoare *et al.*, 2019).

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94. A black day for a blackfly (*Simulium paraloutetense*)

The Gran Canaria blackfly (*Simulium paraloutetense*) was long known only from specimens collected in 1931 from Las Lagunetas, Gran Canaria, by Finnish entomologist R. Frey (Crosskey, 1988; Crosskey *et al.*, 1999). And when Crosskey (1988) described the species, he believed that no springs remained on Gran Canaria, and hence this rare endemic was extinct.

Thankfully, however, as the paper was going to press the species was rediscovered by Marco Báez (Crosskey, 1988:355). Additional specimens were subsequently collected at all stages of their lifecycle and these were described by (Crosskey et al., 1999). However, the species was again reported as probably extinct by (Crosskey & Báez, 2004) on account of its only known remaining habitat being destroyed. It has never been reported since.

Thankfully, there are several high-profile cases of the rediscovery of dipteran species. Arguably, the equal least effort ever exerted to rediscover a species was when a Basilewsky's cranefly (*Dicranomyia basilewskyana*) flew into entomologist Liza Fowler's car in January 2016 (https://shorturl.at/covAD). In contrast, the bizarre Terrible hairy fly (*Mormotomyia hirsuta*) from eastern Kenya was known from two collections in 1933 and 1948 at seemingly the same cleft boulder perched on top of Ukasi Hill. Over the next 62 years numerous attempts to re-find the species failed until November-December 2010 when it was searched for during the short rainy season (Copeland et al., 2011).

While three morbid species of so-called 'bone-skippers' have each been rediscovered after well over a century (Michelsen, 1983; Gómez-Gómez et al., 2008; Carles-Tolrá et al., 2010). Lastly, *Rhaphiomidas terminatus terminatus* now occupies a single patch of 49.42 acres (20ha) in the middle of a Los Angeles golf course (George & Mattoni, 2006).

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95. The ghost of the forest (*Stenostomum tomentosum*)

In 1784–86 Swedish botanist Olof Swartz collected plants in Jamaica for his personal collection, including the holotype of *Stenostomum tomentosum* (then *Laugeria tomentosa*) which he described in 1788. For almost two centuries this was the only record of the species, a tree on a moderately sized island (10,991 km²).

With only a single herbarium record (with no precise locality data) made long before fast and efficient communication, it stands to reason that somebody might have been unaware of Swartz's precedent and subsequently describe the same species under another name. Yet that seems never to have happened, despite faraway European botanists transferring it to different genera over time and thus clearly aware of it. It simply went unnoticed by those on Jamaica itself, until botanist George Proctor found a second specimen on Trelawny Parish in 1975 (Proctor, 1982). Yet his words were to become all too prophetic:

"Unfortunately, the area in which it was found is rapidly being cut over and denuded, so the ultimate survival of this and other rare species is in grave jeopardy" (Proctor, 1982:302).

That was the last time anybody knowingly saw the species again. A remarkable rediscovery after almost 200 years should have lead to the species' protection and propagation. Instead, it was left to its fate, the last tree (or trees) chopped down by those who had not the slightest clue what they were doing. As the last tree's limbs were hacked off, enacting its fall from the Tree of Life, its blood (sap) was on the hands of its ignorant killers. With very few people even knowing of the species, let alone being able to identify a living specimen from a flat piece stuck to a piece of paper in a drawer thousands of kilometres away, the species as originally described (*Laugeria tomentosa*) could easily have been forgotten. The preservation process often distorts specimens, making it difficult to imagine what living individuals might look like.

Yet even with this in mind, the fact is that individuals of *Stenostomum tomentosum* needn't be identified as that species in order for someone to notice that the tree did not fit the description of any other known Jamaican species. Putting the names "*Stenostomum tomentosum*" and "*Laugeria tomentosa*" to the side, a unique tree was ignored for the best part of 200 years. And there is now scarcely anything to mourn apart from a few dried leaves that will hardly move the average person.

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96. A not so egg-cellent identification (*Genyornis newtoni*)

In about the year 50BCE, an Elephant bird (*Aepyornis maximus*) mother frantically scans the ground looking for her single giant egg, the guarantee that her genes will be propelled into the next generation. Meanwhile, the 1ft long egg tumbles down the beach and into the surf where it is washed out to sea and drifts, slowly receding into the horizon. From its home in Madagascar, it floats nine thousand kilometres across the Indian Ocean until it comes to rest on a Western Australian beach.

In late 1992 and after roughly two thousand years (400 years after the species became extinct), it was now high up in the dunes where three children (Jamie Andrich and his two cousins) discovered it just north of Cervantes. Even more remarkably, it was the second such find after the 1930 Scott River egg (Long *et al.*, 1998). And with more than 20,000km of coastline, it is possible that other giant prehistoric eggs remain buried in Western Australian sands a world away from their origin.

For decades prehistoric eggshell fragments from a very large extinct Australian bird were attributed to *Genyornis newtoni*, the last of the dromornithids (Williams, 1981). While some bones of *Genyornis* were known, it was these eggshell fragments that provided us with the extinction date of around 50,000 years ago for the species (e.g. Bird *et al.*, 2003). But there was a problem: the reconstructed size of these eggs are comparable to those laid by the living emu (*Dromaius novaehollandiae*), a bird of around 30–40kg, while *Genyornis* females weighed almost 200 kilograms (Grellet-Tinner *et al.*, 2016, 2017).

An overlooked candidate is the giant extinct megapode *Progura* (and *Latagallina*; see Shute *et al.*, 2017), which would also help explain the abundance of such fragile eggshell remains, as the species likely incubated its eggs in the sand thus protecting them. While new research has dated *Genyornis* bones to 50ka, thus demonstrating its survival well into the Late Pleistocene, although these late survivors had to contend with severe bone infections (McInerney *et al.*, 2021)

Apart from the prehistoric extinctions of *Genyornis*, *Latagallina* and *Progura*, three insular subspecies of emu became extinct historically in Australia. Two of these, the Kangaroo Island emu (*Dromaius novaehollandiae baudinianus*) and the King Island emu (*D. n. minor*) are enigmatic, known only from brief accounts as well as some bones, eggshell and a few skins (Thomson *et al.*, 2018). The Tasmanian emu (*D. n. diemenensis*) is somewhat better known (Dooley, 2017; Eberhard, 2020). In fact, the proportionately high extinction rate of flightless birds over the last 100,000 years has concealed how common the independent loss of flight was in geologically recent bird lineages (Sayol *et al.*, 2020). Extinctions can be biased in all sorts of ways, distorting our perception of the natural world.

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97. One giant leap for a...Goliath frog (*Conraua goliath*)

The world's largest living frog is the aptly named Goliath frog (*Conraua goliath*) from West Africa. Growing to more than a foot long, it can jump up to three metres. And until recently, that might have been its greatest claim to fame, along with its extreme longevity of 15+ years in the wild. But recently local reports of Goliath frogs rolling rocks up to 2kg to build their nests (ponds) have been verified by science (Schäfer *et al.*, 2019).

West Africans knew of this rock pushing behaviour long before scientists, illustrating how little is known by science about even large species (with weight exceeding 3kg in some individuals), partly because there are literally millions of species to be studied. It also poses the question of what came first, the giant frog or the big rock? Were Goliath frogs already very large when they evolved to construct large ponds from rolling miniature boulders? Or did they increase in size to be able to roll larger stones?

Yet despite the enormous size of adult Goliath frogs, their tadpoles are of a far more ordinary size (around 5cm). Tadpoles are so familiar to us that it is very surprising for many people to hear that there are frogs and toads that lack such a life stage, which is called *direct development*. The somewhat smaller American bullfrog (*Lithobates catesbeianus*), by all accounts a very large anuran, has relatively massive tadpoles. But two 'freak' tadpoles were truly enormous. The first discovery took place on 11 December 2007, when a tadpole measuring 19.7cm (7.75 inches) was found (Schooley *et al.*, 2008). The later discovery of the aptly named 'Goliath' at 25.7cm (10.1 inches) in 2018 made it the world's largest known tadpole. Both of these tadpoles ceased metamorphosing but continued growing, allowing them to attain mind-boggling sizes.

In Australia as in many places around the world, the Cane toad (*Rhinella marina*) is an introduced pest that is so successful because it is toxic to many species as both tadpoles and toads. With no natural predators in Australia (being native to South America) the species has travelled across the country at an increasingly fast rate due to the evolution of longer back legs while in Australia. But the most unfortunate impact has been the common misidentification of native frogs as cane toads, resulting in many innocent deaths. A similar problem pertains to our native Australian rodents (especially *Pseudomys* spp. and *Rattus* spp.) which are often mistaken for their introduced cousins. Being able to correctly identify species in your local area is a personal investment in the future of native species in your area.

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98. "I thawed I saw a...Rocky Mountain locust!" (*Melanoplus spretus*)

The body of the animal slowly emerges from its icy tomb after thousands of years. Not a mammoth, nor any other ice age giant. It's one of probably thousands (or millions) of frozen individuals of the now extinct Rocky Mountain locust (*Melanoplus spretus*). An agricultural pest on par with the Passenger pigeon (*Ectopistes migratorius*), both of which formerly numbered in the billions (or more) but have been extinct since the early 20th century (Lockwood, 2004). A seemingly indestructible wave of mouths swarming across the western United States, devouring every crop plant they touched. The so-called Albert's Swarm was estimated at more than 500,000 sq km, and no that is not a typo (https://en.wikipedia.org/wiki/Albert%27s_swarm).

Yet their mysterious disappearance hints at both their vulnerability and our complacency. As far as anyone can tell, their presumed egg-laying grounds in the Rocky Mountains were unknowingly destroyed by farmers and their livestock during the late 1800's. Only a hypothetical disease could otherwise cause such a widespread decline, for which there is no evidence. As there is no evidence of a slow decline in the species' genetic variation (Chapco & Litzenberger, 2004).

Like those extinct species known only from a few specimens, the trillion strong global population yielded little hard data because it was considered a pest species. There was simply no interest in trying to understand the species, only in eradicating it. Yet it was the introduction of large-scale agriculture that likely greatly increased the species' food supply, turning it into the voracious monster that it became in the first place. But even in death we can yet learn more about the species, like the thylacine, from new technologies and methods of study.

For example, it may be possible to reconstruct the species' pre-European diet. Because in Montana lies Grasshopper Glacier which has entombed many grasshoppers of different species over the ages, greatly increasing the *hypodigm* of the species. But in the end, inconvenience to humans is a terrible standard as to what deserves to live and what must be driven extinct. All species have life histories that are as natural as every other, making them equally worthy of conservation.

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99. Sucking the life out of a parasite (*Colpocephalum californici*)

The desire to save every single species seems to cease when we talk about parasites, even though it is the most common mode of existence among animals: parasites outnumber their hosts. There is no documented case whereby the host-specific parasite of a very rare species has needed to be driven extinct to save the host species. While at least one conservation plan to save a host-specific parasite has been published (Pérez *et al.*, 2013).

Almost without exception, parasites have disappeared because their hosts have either become extinct or are so endangered that the infection/transmission rates are too low for the parasite to survive (Dunn, 2009; Rózsa & Vas, 2015). In one case, the global population of the California condor (*Gymnogyps californianus*) was brought into captivity to save them. Two of the birds were infected with an unknown species of louse (order Phthiraptera), very possibly the host-specific Condor louse (*Colpocephalum californici*) (Price & Beer, 1963). Instead of ascertaining whether they were, the two bird were treated, killing the louses.

The louse was forced into extinction despite the co-evolution of the parasite and host over many thousands of years prior to human interference. A parasite that is too successful will be fatal to its host/s, stopping its own spread and engineering its own extinction (like viruses). The natural balance between parasite and host was thus generally maintained until we humans arrived on the scene and started endangering both.

This is even more evident when we consider that a single host can be a receptacle for many different parasites. And while some parasites can survive on different hosts, many of those are actually life stage-specific periods so they are not true generalists (Wait, 2022). Like it or not, the fleas on a dog (or any other example you care to substitute in) are only doing what they have evolved to do, and deserve to live.

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100. One man's Magnificent story of obsession (*Planorbella magnifica*); one woman's voice of life (*Caladenia audasii*)

In 1996, Andy Wood ran outside and grabbed 25 snails and put them in an aquarium in his son's bedroom. But this was no ordinary situation. Hurricane Fran was in full force with widespread flooding, and the 25 snails were individuals of *Planorbella magnifica*, one of relatively few species to have a common name: the Magnificent ramshorn. After the storm subsided 12 of the snails died, leaving the remaining 13 individuals to constitute the entire known global population (McRae, 2014).

Only a decade earlier in 1986 had it been rediscovered (Adams & Gerberich, 1988). While Wood had rescued them from his own backyard refuge for the species, built at no small cost, which had itself been the last known colony. He had in fact rescued the species twice. He has also been instrumental in saving the extinct in the wild Greenfield ramshorn (*Helisoma eucosmium*), another snail that had been rediscovered before disappearing from the wild (Adams & Brady, 1995).

A world away in eastern Australia, the lady dubbed the 'Orchid Whisperer' (Julie Whitfield née Radford) tends to hundreds of native Victorian orchids inside the laboratory she shelled out AU$30,000 (US$ 21,378) to build. She has managed to propagate a number of extremely rare species, including growing more than 97% of the global population of *Caladenia audasii* (McIvor spider-orchid) at one point (Gibson, 2019). Thankfully, the prospects for her orchids are far better than for Wood's snails. With her dreadlocked hair secured, she plants out the orchids she propagates when the time and season are just right. Returning them to the wild where all species truly belong.

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Bonus

Ancient survivors from the deep past (Stromatolites)

In a few very special places around the world, living life forms far more ancient than any other can be seen. They are global tourist attractions, where people gather around marine shores and hypersaline lakes to stare at what appear to be inanimate rocks. Incredibly, they also constitute the world's earliest known fossils, around 3.4 billion years old near Marble Bar in Western Australia's Pilbara region. They are stromatolites, from the Greek strṓmatos (layer, stratum) and líthos (rock), communities of micro-organisms that imperceptibly build layer upon layer of biological sediment.

Despite living specimens often being thousands of years old, they are still being discovered, including within environments that they have not previously been reported from. Tasmania is world famous for the Tasmanian devil, thylacine, UNESCO World Heritage Area forests, apples, the Giant freshwater crayfish (*Astacopsis gouldi*), and many things besides. But it is not a place that comes to mind when you think "stromatolites". Well recent research suggests it *should* be.

Living stromatolites were unknown in Tasmania until 4 December 2015 when they were found occupying a spring mound in peat swamps in the state's south-west (Proemse *et al.*, 2017). A habitat type that had not previously been reported for living stromatolites, suggesting that they may therefore be more widespread globally than previously thought. While this is truly exciting, as the more living stromatolites there are to study, the more (accurate) data that can be generated, it also comes with a general risk.

As a general rule for us humans, the more of something that exists, the less we value it. And if many more living stromatolites are found in the future, then their incredible nature as living examples of the oldest known form of life may be undercut. But there is potentially another problem here too: the artificial comparison of today's natural world with that of ancient versions of the Earth, most notably the dinosaur era and the megafauna era, that steal attention away from what is happening now. Small species need saving just as much as large species.

There is no doubt that dinosaurs capture the public imagination, much of which is grounded in good science and much of which is fanciful, perhaps best epitomised by the Hollywood movie Jurassic Park and its associated sequels. While the ice age giants are also widely associated with a Hollywood movie franchise: Ice Age. And both are associated with the notion of resurrection/cloning. Yet as interesting and worthy of study as these animals (and their associated plants) are, they are not in danger of extinction. They have already been lost, and the bone beds that contain their remains which will increase our knowledge of them are not (in general) going anywhere anytime soon.

If what you care about are the largest species during any given period in the Earth's history, then today should be your priority. Right now, out of *all* of the periods in the Earth's biological history, both the largest vertebrate and largest invertebrate known

to have ever existed are alive: the Blue whale (*Balaenoptera musculus*) and the Colossal squid (*Mesonychoteuthis hamiltoni*). And they do not exist in a vacuum. They require healthy ecosystems full of smaller species plying their evolutionary trade in quest of the ultimate goal: the perpetuation of their kind into the distant future. Don't let these titans disappear, because our world will truly be the poorer for it.

Today is also the temporal anchor between the past and the future. Life is a paradoxical combination of fragility and resilience, and life will go on no matter what we do to the planet within reason. But when all is said and done and our species finally leaves the planet, what shape will the biosphere be in?

There is a powerful analogy here to the story of Noah's Ark. Human influence now encompasses not only planet Earth but stretches far into outer space; from plastic at the bottom of the Mariana Trench to space debris. With such influence and intelligence as we possess, we are not merely just another species, we are custodians of the universe. And the planet is essentially a giant ark where life can thrive, contrasted with the vastness and coldness of space. But unlike Noah's Ark, our ark is haemorrhaging species. Leaving the distinct possibility that when the terrible flood (i.e. us humans) has subsided, leaving those left inside to emerge and repopulate the world, its doors will open and there will be nothing.

The world is full of truly amazing species, if only you would give them a chance.

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