Crime and Pangolins

A Mammalian Murder Mystery

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Preface: A Mystery Deepens

The early months of 2020 were a wild, anxiety-ridden whirlwind for most of humanity. I was in Hong Kong in January of that year when the news of a "novel pneumonia" from Wuhan first started trickling out into the media. Nobody knew much about this illness, but with the memory of the SARS virus that had hit Hong Kong so hard a mere 17 years earlier still vivid, the city began donning face masks immediately. Like many expatriates in the city, I personally did not think much of it and flew to Beijing on a work trip on January 17—I did not even wear a face mask.

I was interviewing high school students for potential admission to the University of Hong Kong (HKU), my employer then and now. I was set up in a nice hotel, and we spent a few days meeting groups of students from far-flung areas of China. When one student mentioned travelling from Wuhan, I remember restraining myself from cracking a joke about the novel pneumonia that was spreading there. It felt far away, non-threatening. My wife Marie had joined me that week to spend some time in Beijing, a city we both love exploring. However, when she arrived at the hotel, she was quickly felled by a nasty virus, eventually ramping up to the worst flu she had ever experienced. To keep spirits up we did indeed crack jokes to each other that this was probably the novel pneumonia.

Because she was so sick, we did not end up doing any sightseeing after all, and we headed back home to Hong Kong on January 21, 2020. Fortunately, Marie had largely recovered by that point. By the time of our return, everyone was talking about the coronavirus outbreak and wearing masks well before any laws were in place requiring them. On January 23, the city of Wuhan underwent a lockdown and suddenly panic was widespread. This seemed like it could be serious and no one was laughing at a sneeze anymore.

By January 27, I was receiving emails from HKU providing a range of social distance measures we were supposed to stick to given the emergence of the coronavirus outbreak. We were also advised against visiting the Chinese mainland (a bit late for that advice, in my case). On January 29, recent visitors to the Chinese mainland were required by the university to undergo "quarantine," meaning we

could not come to campus for 14 days. That included me, of course, thanks to my Beijing travels. That day, I headed out and met a couple of friends at a bar to discuss the bizarre events. At that point, nobody had really processed what the "quarantine order" meant other than that I could not come to campus for a week. By January 31, the university had all but shut down, all teaching had transitioned to online, and we had entered into a new world.

For the month of February 2020, I found myself largely stuck at home. I worked on online teaching material and kept up my research efforts. But I, like most people in Hong Kong and elsewhere, was transfixed by the new developments arising from the coronavirus outbreak. There was a lot of focus in those early months—that remains to this day—about the origins of COVID-19. Where did this virus come from?

In 2013, I read David Quammen's *Spillover*, a book that exerted a large influence on my teaching. Hong Kong's role in the spread of SARS features prominently in the book, and HKU researchers (Malik Peiris and Leo Poon in particular) feature as the heroes who discovered where the virus came from—bats, quite likely with civets as the intermediate host. I enjoyed using this case study in my courses as an example of the important relationships between human, animal, and environmental health. With this mindset, it seemed logical that the COVID-19 coronavirus also likely originated from animals.

In a matter of weeks, evidence began accumulating that COVID-19 did in fact have an origin in animals, similar to those suspected in the original SARS. In early February 2020, a preprint (that is, a scientific paper not yet subject to peer review) was published by Zheng-Li Shi's lab in the now famous (or infamous, if you are a fan of Fox News) Wuhan Institute of Virology, showing that the virus responsible for COVID-19, SARS-CoV-2, was closely related to a virus found in a bat from a cave near Wuhan; the virus was called BatCoV RaTG13.[1] Perhaps, like the original SARS, COVID-19 had its origins in bats. But the viruses were sufficiently distinguished from one another that there could not have been a direct transmission of that virus from bats into the human SARS-CoV-2. Could there have been an intermediate host?

Less than a week after this news came out, another preprint was released, showing that SARS-related coronaviruses had been discovered in pangolins seized by government officials in the Chinese mainland.[2] Suddenly, news about pangolins was spreading everywhere. Twitter was aflutter with the possibility that Asia's

1. Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., . . . Shi, Z. L. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, *579*(7798), 270–273.
2. Lam, T. T. Y., Jia, N., Zhang, Y. W., Shum, M. H. H., Jiang, J. F., Zhu, H. C., . . . Cao, W. C. (2020). Identifying SARS-CoV-2-related coronaviruses in Malayan pangolins. *Nature*, *583*(7815), 282–285.

exploitation and trade of pangolins might have led to the emergence of SARS-CoV-2. The journal *Nature* quickly published a news piece titled "Mystery Deepens Over Animal Source of Coronavirus" featuring a large photo of a pangolin.[3]

Here is where my casual interest in the origins of COVID-19 collided with my professional interests and experience. At that point, I had been studying pangolins for several years and had become something of an expert in the trade of these charismatic species. I dove into the preprint with great interest. To my surprise, I discovered that the team who discovered these viruses in the pangolin trade were also from my university, based in the Faculty of Medicine at HKU.

Tommy Lam of HKU was the first author and lead on the paper. Even more coincidentally, a former research assistant in my lab, Brian Worthington, was now pursuing a PhD and being co-supervised by Tommy. I immediately got in touch with Tommy and Brian and asked whether they would be interested in collaborating on the topic of links between pangolin trade and viruses, and coronaviruses in particular. They were. The three of us had a couple of quick meetings and I started drafting up a grant proposal.

With a range of partners across HKU and outside, we wrote up a quick pre-proposal for Hong Kong's Research Grants Council. They had a new funding program called the Research Impact Fund, which was designed to support applied research. This seemed like an important issue at the time and so I thought we might have good odds of funding success.

In the proposal we wrote:

> The full global impact of COVID-19 is not yet known, but already, three months into the crisis, there have been enormous consequences for human life (over 2,000 deaths and over 75,000 cases at the time of this writing). There are also broader societal impacts and economic losses that are difficult to imagine and harder yet to quantify. The current public health priority is, of course, to stop the current transmission and contain the virus. However, the source of the virus must also be found to ensure that this does not happen again and enable effective regulation of wildlife trade markets (assuming this did indeed come from wildlife trade as is widely understood).

It feels odd at this point to feel the need to highlight the importance of COVID-19. But in February 2020, most of the United States was going on with their lives, as if all was well. I also remember writing about "2,000 deaths" and knowing that that number would not be the end of it. However, never in my wildest imagination would I have predicted that more than 7 million people would eventually perish from the virus (as of 2023). It was not until March that things started blowing up in the US,

3. Cyranoski, D. (2020). Mystery deepens over animal source of coronavirus. *Nature*, *579*(7797), 18–20.

and it took until March 11, 2020 for the World Health Organization to declare a global pandemic. Our proposal was eventually funded in late 2020 and much of my own research on pangolins, which I will describe in the pages that follow, derives directly from this generous research support from the Research Grants Council of Hong Kong.

At the time I was drafting the proposal, I also started calling contacts at Hong Kong's Agriculture, Fisheries and Conservation Department (AFCD). The international trade of pangolins (scales, meat, or any other part of them) is regulated by local and international law, specifically the Convention on International Trade in Endangered Species of Wild Fauna and Flora, or CITES. If anyone is caught trying to smuggle pangolin products into or out of Hong Kong, the AFCD would be the agency responsible for investigating (along with the Customs and Excise Department, the police, and others).

It took me some time to get through to anyone at AFCD. It was a chaotic time for all of us, but eventually I did.

"Hi, I'm Tim Bonebrake, a professor at HKU studying pangolins. We've previously arranged the transfer of pangolin scales to the university. You may have seen some of the news recently linking pangolins to newly discovered coronaviruses. I was wondering whether you had any seized pangolin *carcasses* in storage that we might be able to analyze for viruses?"

"As a matter of fact, we do. You want them?"

It was that easy. Well, alright, not exactly that easy. We went through quite a bit of paperwork and many phone calls to arrange the official transfer of pangolin carcasses from AFCD to HKU. There were also some major logistical hurdles. AFCD let us know that they had several boxes of the pangolin carcasses in a cold storage facility, so we had to rent a truck and then figure out what to do with all of the carcasses.

We teamed up with a veterinarian, Paolo Martelli, at Ocean Park. He offered their marine mammal necropsy facility as a location to process the pangolin carcasses. He also generously volunteered his own time to lead the necropsy of all individuals.

Finally, on May 21, 2020, everything was set. Brian had done most of the legwork to coordinate everything and prepare everyone for the task ahead. We pulled the truck up to the cold storage facility. Out came 14 large Styrofoam boxes, all filled with dead pangolins.

The AFCD officer who I had initially spoken to on the phone months prior was there to oversee things. I asked her how many pangolins were in the boxes.

"We don't know—we haven't done a count, just an estimate. Maybe 40 or 50 based on the number of boxes. We don't know much at all about these pangolins, actually. These were seized in 2018, but the smugglers got away. So we really don't

know much." Later that week we completed a full count—there were 88 frozen Sunda pangolins tightly packed in those boxes.

I thanked the AFCD officer for the department's generosity in transferring the carcasses for our research. As we quietly watched the boxes and boxes of dead animals get loaded onto the truck, she finally turned to me and said earnestly, "If we can learn anything from these deaths, that's all I care about. Good luck."

This is a book for and about those 88 pangolins. Where did they come from? Who hunted them? Who traded them? How did they end up in Hong Kong? Where were they going before their journey was interrupted by seizure? What are the conservation and ecosystem consequences of the loss of those 88 pangolins from their natural homes? Do these pangolins carry coronaviruses? Now that people associate pangolins with COVID-19, will the exploitation of these species slow?

At its core, this is a mammalian murder mystery. It's the mystery behind this specific case of the 88 pangolins but it also extends to the murder of millions of pangolins every year.[4]

In the following chapters we will dive into the daily lives of pangolins, review the evidence surrounding the killing of pangolins, and meet the suspects behind the killings. Once all the evidence is in hand, we will look to see who should be held responsible and how they should be accountable. Finally, we will answer the question: how do we make this world safe for all pangolin species across the world?

To meet these objectives, we will need to travel all across Asia and Africa—the vast domains of pangolin species globally. We must learn more about the animals themselves but also about the people tied to the species: the communities who share their homes with pangolins, the hunters, the traders, and the consumers of pangolin products. We need to explore the complicated international connections that now underlie the supply and demand dynamics driving pangolin trade. We also need to carefully study how pathogens (and coronaviruses specifically) relate to pangolins, and whether the trade of these species may pose a danger to humanity. And finally, we need to ask: What are the policy implications of possible pangolin and pathogen relationships?

In the course of my decade of research on pangolins, I have been fortunate to come across some absolutely unforgettable personalities. I want to take the opportunity here to highlight these characters. This includes the pangolin researchers, conservationists, and the pangolins themselves, of course. When I personally need inspiration or hope about conservation, these are the heroes I look to.

4. Ingram, D. J., Coad, L., Abernethy, K. A., Maisels, F., Stokes, E. J., Bobo, K. S., . . . Scharlemann, P. (2018). Assessing Africa-wide pangolin exploitation by scaling local data. *Conservation Letters*, *11*(2), e12389.

Pangolins are in trouble—there is no question about that. And yet, there are plenty of reasons for optimism. This is a celebration of these fantastic species and the continuing mysteries that cloud their natural histories. We still have an abundance of time to reverse the narrative of pangolin overexploitation and decline and transform their story into one of recovery and persistence. As I will detail through a number of stories and studies, we have already started down this pathway.

A little over a year after I started my research on pangolins and pathogens, I received my first COVID-19 vaccine shot in April 2021. This was a tremendous scientific advancement and victory, spurred by the urgency of the spreading virus and guided by brilliant and dedicated researchers. I shudder to think what the world might look like now without our vaccines to combat the worst effects of SARS-CoV-2. Seeing how effectively we have fought this global pandemic, I know we certainly have the capacity to save pangolins . . . but the question is whether we have the will to do so.

1
The Victim: Life of a Pangolin[1]

Once we had trucked all of the boxes of dead pangolins to the necropsy facility at Ocean Park, we suited up in biohazard personal protective equipment (PPE) and began unpacking the individuals. Each pangolin had been wrapped in plastic with a barcode stamp and the weight of each individual was recorded on the tag—they were all clearly processed in one location. The pangolins were curled into their familiar pangolin balls and frozen stiff. We carefully removed all of the packaging and transferred the pangolins to large garbage bins for ease of storage, recording all of the details we could as we went. This was a large team effort coordinated by Brian Worthington (PhD student at HKU at the time) and Paolo Martelli, lead veterinarian at Ocean Park, assisted by several technicians and veterinarians from both HKU and Ocean Park. I was there with Tommy Lam and an ecologist colleague of mine at HKU, Caroline Dingle.

At the time, we did not even know what pangolin species comprised this seizure, though we were quite sure it was mostly or entirely Sunda pangolin. This is the most common pangolin species in Asia—though now not as common as it once was. As we unpacked the bodies, it was clear that all of the scales had already been removed by being boiled off. But Paolo, who had experience caring for pangolins, knew how to identify their species based on the size and number of scales on their tails. Mind you, the bodies had no scales, but the imprints of scales on the bodies were clear and so it was still possible to identify them in this way. All of the 88 individuals were identified as Sunda pangolins.

1. Note on conservation and data sensitivity of the book: Some of the details surrounding pangolin conservation are ecologically or legally sensitive, or both. For example, exact locations of pangolins have been left out and at times obfuscated in the interests of keeping those locations protected. When necessary, I have omitted or changed details to protect both the species and people discussed.

The unpacking took the better part of a day. We opted to do just one or two necropsies that afternoon and continue the efforts the next day. We were not sure how long it would take to process all of the bodies. It ended up taking several weeks.

Taking the first body, we uncurled it from its rolled-up position. The body was pale and naked, without its scales. Paolo took a number of measurements, called out loud for the measurements to be recorded, and started cutting into the belly of the pangolin with his scalpel. Meanwhile, Brian readied his own array of long cotton swabs for swabs and medical scissors for samples. As Paolo cut in and made other remarks on the condition of the pangolin, Brian started swabbing the nasal cavities and cutting pieces of the organs. Curiously, the organs had all been cut out and placed in a bag, then put back into the body cavity.

That first pangolin took several hours to get through completely, and the first few days were emotional for me and others. Just seeing all of the bodies of this endangered species taking up space in garbage bins was devastating. But by the 88th necropsy, our team had become quite adept and efficient with the data recording and sampling. There was a clinical and nearly industrial feel about the whole process.

* * *

All pangolins have scales—this is their key defining and uniting feature. Scales are unique in mammals. Many people may note a passing resemblance to armadillos, but armadillos have a leathery shell, not scales. The scales on pangolins are essential for defense from predators. You may have seen one of many documentaries featuring lions enjoying a game of pangolin ping-pong as they toss a rolled-up pangolin and try in vain to pry it open for their dining pleasure.

The shape and size of scales can vary a lot both within and across species. Even within an individual pangolin, the scales on their back will tend to be quite a bit bigger than those on their feet or head. The general shape of pangolin scales is somewhat consistent, like large fingernails, but sometimes narrower and other times broader (depending on the location on the body and the species).

The number of scales on any given pangolin can also vary significantly. Researchers in 2019 examined pangolins from museums across the US and UK, finding 66 pangolins in all.[2] They then counted individual scales for all of them in what I am certain was tough and tedious work. The Temminck's ground pangolin averaged the fewest number of scales with 382 while the Philippine pangolin had the most with 940. The Sunda pangolin averaged 867 scales per individual based on

2. Ullmann, T., Veríssimo, D., & Challender, D. W. (2019). Evaluating the application of scale frequency to estimate the size of pangolin scale seizures. *Global Ecology and Conservation*, *20*, e00776.

the 11 individuals they sampled. These numbers turn out to be very important in quantifying the impacts of the trade of scales as we will see.

Pangolin scales have been studied in some detail at a structural level as well. At first glance, the scales do not seem to be arranged in any clear order. But pangolin scales tend to be arranged in a hexagonal pattern–that is, one scale will have three scales above it that partially covers the scale where it attaches to the body, while that scale will simultaneously partially cover three other scales below it. There is also variable overlap between the scales covering one another; Chinese pangolins (*Manis pentadactyla*) exhibit lower overlap of about 20–30% while white-bellied pangolins (*Phataginus tricuspis*) exhibit between 40–70% overlap.[3] The structure and configuration of these scales provide significant flexibility for animal movement while also providing maximal protection from predators.

Of all the 88 pangolins we surveyed, few had any remaining scales left (and the few that did only had a couple). There is a market for pangolin meat and a market for pangolin scales, but these tend to be for very different purposes. We suspect that the scales were boiled off and then transferred to someone else for sale and distribution.

* * *

The function of scales is clearly to fend off large predators. Lions and tigers are among the more formidable predators for many pangolin species.[4] Large reptiles are also known to eat pangolins—crocodiles and pythons in particular. Once confronted by a predator, the animals will curl up into a ball and protect their otherwise exposed body parts (like their face, for example).

The ball-curling behavior has some interesting consequences. In Chinese pangolins, there are records of the animals curling up into a ball and rolling down slopes to escape predators.[5] Some predators probably see this ball of scales and, knowing the difficulty of extracting the actual meat from these configurations, give up and move on to other things.[6] However, the ball curling can unfortunately also make it

3. Wang, B., Yang, W., Sherman, V. R., & Meyers, M. A. (2016). Pangolin armor: Overlapping, structure, and mechanical properties of the keratinous scales. *Acta Biomaterialia*, *41*, 60–74.
4. Chao, J. T., Li, H. F., & Lin, C. C. (2020). The role of pangolins in ecosystems. In D. W. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins: Science, society and conservation* (pp. 43–48). Academic Press.
5. Wu, S., Sun, N. C. M., Zhang, F., Yu, Y., Ades, G., Suwal, T. L., & Jiang, Z. (2020). Chinese pangolin *Manis pentadactyla* (Linnaeus, 1758). In D. W. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins: Science, society and conservation* (pp. 49–70). Academic Press.
6. Peplinski, J., Malone, M. A., Fowler, K. J., Potratz, E. J., Pergams, A. G., Charmoy, K. L., . . . Brown, J. S. (2021). Ecology of fear: Spines, armor and noxious chemicals deter predators in cancer and in nature. *Frontiers in Ecology and Evolution*, *9*, 682504.

easier for human hunters. Once in a ball, the hunter can simply take the pangolin alive, place it in a bag, and continue hunting.

Scales must be effective for defense as the weight of scales can amount to one third or one quarter of a pangolin's body weight.[7] In a study of mammal brain sizes, researchers Stankowich and Romero[8] looked at morphological features of over 600 mammal species. Pangolins, interestingly, have a relatively small encephalization quotient, which is the size of the brain relative to the animal's body size. In other words, as they speculate, "this tremendously effective defense [ball rolling] renders pangolins and armadillos relatively safe from most predators, reducing selection favoring superior intelligence, detection, and predator assessment." Who needs brains when you have body armor?

Pangolins are therefore defined by their scales. This is how humans characterize the uniqueness of these animals and set them apart from other species. Scales are also immensely important in the evolution of these species and provide a key protective armor from the range of predators that would otherwise consume them efficiently and without issue.

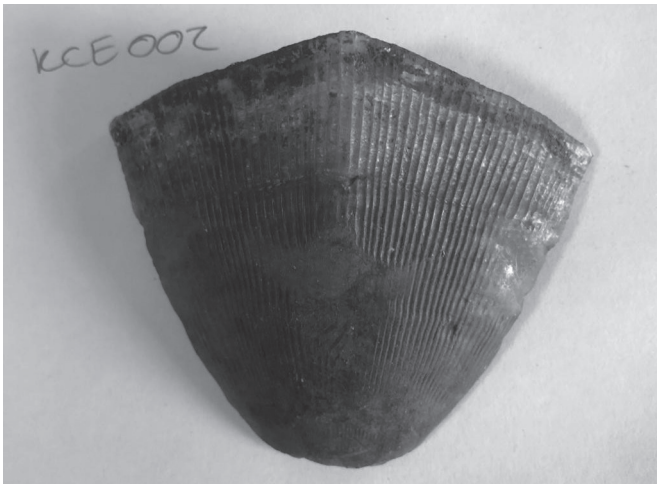

Figure 1.1. Giant pangolin scale from a seizure in Hong Kong. Photo courtesy of Tracey-Leigh Prigge.

7. Wang, B., Yang, W., Sherman, V. R., & Meyers, M. A. (2016). Pangolin armor: Overlapping, structure, and mechanical properties of the keratinous scales. *Acta Biomaterialia*, *41*, 60–74.
8. Stankowich, T., & Romero, A. N. (2017). The correlated evolution of antipredator defences and brain size in mammals. *Proceedings of the Royal Society B: Biological Sciences*, *284*(1846), 20161857.

* * *

If the pangolins can keep from being eaten by other animals through their scales, what do the pangolins themselves eat? The feeding habits of most pangolins are still rather mysterious, but our knowledge on this aspect of their ecology is growing. All pangolins eat insects and ants, and termites are often a favored treat. This has given them a reputation for being good at pest control within their habitats as they regulate insect numbers.

A study by colleagues of mine at HKU[9] gives a sense of the efficiency of pangolins as voracious insect predators. Roger Lee was a PhD student in 2017 and was supervised by a professor at HKU, Benoit Guénard. Both are ant researchers and they used the carcass of a juvenile Chinese pangolin found killed by dogs to investigate its diet. Within the pangolin's stomach, they discovered a buffet of over 25,000 ants and more than 800 termites. Interestingly, the most abundant ant species discovered in the stomach were arboreal ants, implying that the individual had spent some of its final moments targeting ants in trees for a tasty last supper.

Pangolins are selective in their consumption of prey. Ants typically make up the majority of prey consumption for most pangolin species, similar to the case of the Hong Kong Chinese pangolin. But pangolins will also specifically target certain types of ants in their foraging efforts. In a study[10] of Temminck's pangolin (*Smutsia temminckii*) at a site in South Africa, researchers found a total of 55 ant and termite species from pitfall traps in the area. However, the following of 15 radio-tracked pangolins indicated that 97% of their diets were made up of only six species (of which 96% of the diet was ants). A single ant species, *Anoplolepis custodiens*, made up 77% of their diet, while in the pitfall traps the species comprised only 5% of ants captured.

The large front claws of pangolins are nearly as impressive morphologically as their scales. These large claws are necessary to dig into the ground (or branches for more arboreal pangolin species) and find ants to eat. The claws also allow the animals to traverse complex landscapes and climb trees.

Pangolins also have fabulously long tongues that enable them to slurp up their prey from the holes they dig out with their claws. In the largest of the pangolin species, the aptly named giant pangolin (*Smutsia gigantea*), its tongue can extend up to 70 cm.[11] That's as long as a small baseball or cricket bat. The animal will

9. Lee, R. H., Cheung, K., Fellowes, J. R., & Guénard, B. (2017). Insights into the Chinese Pangolin's (Manis pentadactyla) diet in a peri-urban habitat: A case study from Hong Kong. *Tropical Conservation Science, 10*, 1–7.
10. Swart, J. M., Richardson, P. R. K., & Ferguson, J. W. H. (1999). Ecological factors affecting the feeding behaviour of pangolins (*Manis temminckii*). *Journal of Zoology*, *247*(3), 281–292.
11. Hoffmann, M., Nixon, S., Alempijevic, D., Ayebare, S., Bruce, T., Davenport, T. R., . . . Ndjassi, C. (2020). Giant pangolin *Smutsia gigantea* (illiger, 1815). In D. W. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins: Science, society and conservation* (pp. 157–173). Academic Press.

rapidly push out and retract its tongue to efficiently capture its insect prey. In fact, this behavior of tongue slithering, along with their scales, confused early European taxonomists who were unsure whether pangolins should be classified as mammals or lizards.[12]

Ants and other insects can live on the ground, in the ground, and on trees. It follows logically, then, that pangolins are very good at traveling on the ground, on trees, and underground as well. This is thanks largely to their strong and powerful claws which allow them to grip trees effectively and burrow into the dirt. Some pangolin species spend most of their time in trees while others largely spend their time burrowing into the ground.

The Sunda pangolins from the 2018 seizure in Hong Kong are a semi-arboreal species. The species is nocturnal (as most pangolins are) and rests during the day in tree hollows or burrows in the ground, usually near trees.[13] But aside from a handful of studies, there is relatively little known about the ecology or natural history of this species. Sadly, this is true for most species of pangolin and will be a recurring theme in many of the chapters of this book. These species are rare and getting rarer. Their nocturnal activities and tendency to stay high up in trees or below ground further add to their mystery and the difficulty of studying or tracking them.

The same is true for the Chinese pangolin. I mentioned briefly earlier that there are Chinese pangolins in Hong Kong. For those of you unfamiliar with Hong Kong, or who only know the city for its famous urban skyline across Victoria Harbour, this might come as a surprise. Actually, for many people who *live* in Hong Kong, this may also come as a surprise. But it is true, and I have spent the past few years studying the ecological habits of this curious population thanks to an intrepid and persistent American PhD student, Anna Goldman.

* * *

Anna was not the first student to come to me wanting to study the Chinese pangolins of Hong Kong. My answer to her was the same as to all the students before her: "Sure, go ahead! But . . . I assume you don't actually care about getting your degree on time? You won't be upset by months, perhaps years, of field work that yield zero data about this species?"

12. Lawrence, N. (2020). Early biogeographies and symbolic use of pangolins in Europe in the 16th–18th centuries. In D. W. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins: Science, society and conservation* (pp. 213–225). Academic Press.
13. Chong, J. L., Panjang, E., Willcox, D., Nash, H. C., Semiadi, G., Sodsai, W., . . . Cheema, S. (2020). Sunda pangolin *Manis javanica* (Desmarest, 1822). In D. W. Challender, H. C. Nash, & C. Waterman (Eds.), *Pangolins: Science, society and conservation* (pp. 89–108). Academic Press.

13
Epilogue

The day we loaded the boxes of dead pangolins into a truck to be processed for samples, I stood on the edge of the loading dock and wondered: "How did this happen?" I was desperate for answers. I wanted to know what type of pangolin species these were, how they died, where they came from, whether they had coronaviruses, where they were heading to . . . but I also wanted to know what all of this meant for pangolins more broadly.

I cannot answer all of these questions definitively, but I hope that this book has addressed these mysteries as well as they can be at this point. I truly believe that the data collected from those 88 pangolins will prove invaluable for the Sunda pangolins and the other pangolin species. In the broad sense, those pangolins have received justice.

The story is not over. Brian, Portia, Taneisha, and Tracey are still analyzing samples from that seizure. We are continuing to pursue a variety of exciting scientific puzzles. I am so fortunate to have the opportunity to conduct these investigations. I wake up every morning itching to get to the lab so that I can learn more and piece evidence together to tackle important ecological, evolutionary, and conservation questions.

But I am even more fortunate to work with some truly talented researchers and conservationists. I have done what I can to highlight some of their stories, but I fear I am probably underselling their power and impact. Working in biodiversity can be very dispiriting at times, and there can be a lot of death and despair associated with conservation. Every time I open a bag of seized pangolin scales, the odor of decomposition is an unpleasant reminder of this. My students, colleagues, and collaborators are a vital antidote to these down times.

As long as these talented students, scholars, and advocates continue to devote attention and effort to the conservation of pangolins, I am optimistic for the future of the species. And more community activists, law enforcement officials, scientists, social scientists, veterinarians, and doctors are directing their powers to the cause every day.

I have written previously about Tracey Prigge's key contributions to a number of pangolin research projects in my lab, but I have not yet written about her PhD studies on applications of stable isotope analysis to understand pangolin health and trade (using the 88 pangolin individuals as a key source for samples). This is because she is still working on it, so you will have to stay tuned.

As part of her PhD, Tracey has also recently started working on the Temminck's ground pangolin in South Africa, where Tracey grew up and went to university. The entire global and circular nature of her project is perfect in my mind. Tracey moved from South Africa to Hong Kong, worked on pangolin samples seized in Hong Kong that originated in South Africa, and now (in collaboration with Johannesburg Wildlife Veterinary Hospital) she is going back to South Africa to study those pangolins in their homes . . . and her home. It is a lovely small world.

Recently, for Mother's Day, HKU interviewed the children of women in science at the university. Tracey's 8-year-old daughter Zoe was asked what her mom did and she answered, "She does science . . . she saves pangolins . . . if she doesn't actually save pangolins, they'll go extinct."

Well said. That is basically the point I was trying to make here, in many more unnecessary words and not as eloquently.

Figure 13.1. A Temminck's pangolin, named Simon, waking up from anaesthetic after a veterinary procedure at the Johannesburg Wildlife Veterinary Hospital. Simon was released back into the wild soon after this photo was taken. Photo courtesy of Tracey-Leigh Prigge.

CRIME AND PANGOLINS

A Mammalian Murder Mystery

"The international traffic in pangolins is a vast and heartbreaking criminal enterprise against a group of wondrous, gentle, and almost defenseless creatures. Timothy Bonebrake tells that story and much more in this thoughtful, important book."

—**David Quammen**, author of *Spillover: Animal Infections and the Next Human Pandemic*

"Timothy Bonebrake and a colorful coterie of collaborating sleuths probe the identity, origins, and ultimate destination of 88 mutilated pangolin carcasses seized in Hong Kong. Combining erudition with a light touch, Bonebrake explains how exploitation and trade have depleted wild pangolin populations—and the potential implications for people."

—**David Dudgeon**, The University of Hong Kong

"Bonebrake turns the illegal pangolin trade into a gripping 'mammalian murder mystery,' weaving ecology, conservation, and disease dynamics into a clear-eyed account of how wildlife exploitation reverberates through ecosystems and public health. Readers gain both scientific insight and policy urgency—plus renewed hope that rigorous evidence can drive pangolin recovery."

—**Hillary Young**, The University of California, Santa Barbara

In 2018, authorities in Hong Kong seized a shipment from smugglers that contained 88 dead pangolins. Where did these animals come from, and why were they killed? Where were they going? Who was responsible? In classic true crime fashion, the book examines evidence, suspects, and legal perspectives related to this specific case and, through it, the plight of pangolins globally. The chapters detail the lives and natural history of pangolins across Africa and Asia while exploring clues that may reveal who is responsible for the endangerment of the species. The book also explores speculation surrounding the possible role of pangolins in the emergence of COVID-19 and, more broadly, the relationship between wildlife trade and zoonotic disease. The resulting tale is one of conservation researchers, public health experts, and global organizations across Asia, Africa, North America, and Europe fighting to create a world in which pangolins can thrive again.

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