

Traditional Chinese Medicine and Global Conservation Ecology: Remedies for the Future

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Introduction

Traditional Chinese Medicine (TCM)¹ is often directly involved in cases of wildlife conservation and trafficking (Chang 2017). Many species currently face extinction as a result of increased demand for animal products used in TCM. However, the relationship between TCM and conservation ecology has yet to be addressed in a manner that places equal emphasis on both the principles behind these animal-based remedies and the ecological impacts TCM has on species and ecosystems around the world. The discovery and furtherance of animal product alternatives in TCM is indispensable, as a decrease in the demand for animal products would lessen their value and diminish the global incidence of poaching. Here, I present several plant-based TCM remedies to be used in place of tiger bone and pangolin scale (see Table 1). The endangerment of wildlife due to TCM is an issue that extends beyond the scope of conservation biologists; it is both an environmental and cultural concern. Working constructively to lessen the strain TCM puts on wildlife requires an understanding of wildlife conservation, as well as the scientific principles behind TCM, reasons for its rise in popularity, and cultural significance it has to those who practice it.

Banning the importation of endangered animal products into China and other parts of Asia has proven largely unsuccessful, due to lucrative global black-market networks (Nowell 2007; Findley 2010, Challender, Waterman, et al. 2014; Bessesen 2018). A ban on all TCM remedies

¹ Refers to the modern medical tradition invented in the mid-20th century, rather than the collection of natural remedies recorded in ancient China

would also be impossible, given the strong governmental and popular support TCM enjoys. Understanding the history and modern role of TCM will help us understand the global conservation issues TCM fuels and find a solution that will be beneficial to both TCM practitioners and the affected ecosystems. This paper seeks to explore TCM, conservation ecology, and the connections between the two by investigating three animals, all endangered as a result of their use in TCM remedies: tiger, pangolin, and totoaba. Due to the limited body of research concerning the pangolin and totoaba, the preponderance of this paper will address tiger conservation within the context of TCM.

Traditional Chinese Medicine

The remedies and principles behind TCM have a long history. Physicians began systematically prescribing medicinal plants, animals, and minerals in China since before the Han dynasty (206 BCE-220 CE). During this time, herbal remedies were combined with older shamanistic healing techniques to strengthen a patient's *qi* (life force or vital energy) and maintain a balance between his or her *yin* and *yang* (feminine and masculine energies, respectively). By the late Han dynasty, the popularity and legitimacy of shamanism had declined, while empirical medicine continued to evolve and expand (Bensky & Gamble 1989). Each remedy accesses a specific part of the body through a meridian, or channel, and has a unique combination of attributes (including taste, thermal property, and direction), which makes it suitable for curing a particular illness or set of illnesses (Bensky & Gamble 1989; Chen, et al. 2012). The number of remedies known to physicians of native medicine in China has grown considerably over time. The earliest text of native Chinese medicine to be discovered by archeologists, *Prescriptions for Fifty-two Ailments* (*Wushi'er Bingfang*), described only around 250 remedies. In contrast, the *Encyclopedia of Traditional Chinese Medicinal Substances* (*Zhongyao Da Cidian*), compiled by the Jiangsu

College of New Medicine in 1977, contains descriptions of 5,767 remedies (Bensky & Gamble 1989).

Though plant, animal, and mineral-based native remedies have endured in China for millennia, TCM is, in fact, a relatively new concept. Prior to the introduction of Western medicine to China in the late 19th century (Croizier 1965), there were no alternatives to native Chinese herbal remedies; “traditional” and “modern” medical traditions in China are both constructions of the 20th century. In the 1930s and 1940s, the leaders of the Chinese Communist Party favored Western medicine, believing “traditional medicine represented all the backwardness, superstition and irrationality of the old society and culture with which they were locked in mortal combat” (Croizier 1965, 2). This intense distrust of imperial China and native medicine on the part of the Chinese Communist Party, as well as the Nationalist government that preceded it, resulted in an increased number of medical students learning, and subsequently, practicing Western medicine in Republican China (Xu 1997). Throughout the 20th century, the Republican period trended towards a notion of “modernity” that spanned medicine, science, and engineering.

After the fall of the Republic of China, the People’s Republic of China formed, with Mao Zedong as the chairman of the Chinese Communist Party and leader of the state. During the 1950s and 1960s Mao Zedong sought to unite and industrialize the People’s Republic of China with his Great Leap Forward campaign (Hsu 2008). Chairman Mao aimed to project an image of China as a self-reliant state, and so he promoted domestic Chinese medical traditions and created the earliest iteration of TCM, as a symbol of cultural nationalism. This party-endorsed form of medicine incorporated science, while still utilizing traditional remedies. However, Western influences on TCM were still suppressed as much as possible (Croizier 1965).

Since its creation in the 1950's, TCM has evolved, and its role in Chinese society has shifted dramatically. At the time of its conception, TCM was used by the Chinese Communist Party as a tool for rejecting “bourgeois” international influences and ideologies. Government propaganda portrayed TCM as a reflection of Maoist proletarian values and downplayed its connection to imperial China, which was seen by the Chinese Communist Party as contemptible and primitive (Croizier 1965). TCM was meant to be a testament to the success of Mao's modern socialist state. Today, both Western medicine and TCM are present and widely practiced in China. In order to prevent and treat diseases, modern TCM still uses ancient techniques, such as employing *yin*-intensive substances (those that are hot or dry) to counter an excess of *yang* (cold and wet), and vice versa. Because *qi*, *yin*, and *yang* all continue to play important roles in TCM treatments, TCM remains somewhat at odds with Western scientific perceptions (Oshima et al. 2015).

Recently, the Chinese Communist Party, led by President Xi Jinping, has been promoting TCM on a broad scale, embracing it as a “2,000-year-old national treasure” (Xinhua 2014). As a result of party endorsement, consuming TCM products has become a way for Chinese citizens to not only honor Chinese traditions and culture, but also to demonstrate their support of the Chinese state and its leadership. The creation of a new upper-middle class in China has also contributed greatly to the rise in TCM product consumption. Within this newly formed socioeconomic stratum, the demand for animal-based remedies in particular has intensified in the last decade. Animal-based TCM remedies, as well as raw, unprocessed goods, such as rhino horns and ivory, sell for astronomical amounts on the black market, since the obtention, transportation, sale, and purchase of many rare animal products is illegal (Maron 2018). Additionally, Xi Jinping's One Belt, One Road initiative, which emphasizes economic partnerships with Europe and other parts of Asia

(Ferdinand 2016), has brought about increased international demand for Chinese medicinal herbs and animal remedies, due to China's newly strengthened international trade relationships (Xinhua 2014).

Now, China is undergoing an entirely different sort of cultural revolution, and TCM is just one of many aspects of Chinese heritage revived under the current leadership of the Chinese Communist Party. Because the Chinese government now embraces its long imperial history, it is now representing TCM in a way that accentuates the technological advancements China has made over thousands of years. TCM today acts as a crucial part of the nationalist party agenda, an emblem of Xi Jinping's "Chinese Dream".

The Chinese Communist Party's staunch support for TCM does not end at rhetoric. Party representatives have not only extolled the practice of TCM through state-controlled media outlets, but have also passed legislation allowing for more lax regulations on TCM, compared to Western medicine. The National Medical Products Association, formerly the China Food and Drug Administration, now requires fewer regulatory trials of TCM remedies, as long as they are prepared using traditional methods (outlined by the National Medical Products Association). These regulations aim to expedite the production and distribution of TCM products, while potentially putting patients in danger (Cyranoski, 2017).

Since TCM does not need to adhere to the standards that Western drugs are held to, it would be appreciably easier for TCM manufacturers to produce and profit off of fake TCM products or genuine remedies laced with potentially harmful additives. Both spurious and contaminated TCM remedies would be deleterious to a patient's wellbeing. In a best-case scenario, these remedies might fail to effectively cure a patient's illness, while in a worst-case scenario, they might result

in worsening of a patient's symptoms, development of new injurious symptoms, or even death.² In addition, prospective TCM practitioners can obtain their medical license without the completion of a standardized test, and establish a TCM clinic without authorization from the National Medical Products Association (Cyranosky 2017). The promotion of TCM at the expense of patient safety is distressing. Permissive regulations surrounding TCM has resulted in increased accessibility and demand for remedies, including those made from illegal animal products.

Unfortunately, TCM is once again steeped in nationalism, and China's strict censorship policies prohibit Chinese citizens from publicly speaking out against TCM. This means TCM is likely to be an indomitable force as long as the Chinese Communist Party supports it, despite the problematic nature of the state's regulations and the impacts TCM has on conservation ecology in other parts of the world.

Case Study 1: Tiger

In order to investigate the impacts TCM has on endangered species, I will explore three case studies in depth. The first case study, the tiger (*Panthera tigris*), is prominent in the contexts of both TCM and conservation. Tigers are poached extensively for their skins, but also for their body parts, almost all of which have a use in TCM. Tiger bone (*Hu Gu*) is the most common tiger-based remedy. Usually administered in the form of pills and wine (Nowell 2000), tiger bone is an acrid, sweet, and warm substance used for countering "damp" and "cold" illnesses, such as joint weakness, stiffness, bone and muscle weakness, lower back pain and knee pain. The first mention of tiger bone as a medicinal substance was recorded in the *Collection of Commentaries on the Classic of the Materia Medica (Ben Cao Jing Ji Zhu)* (Bensky & Gamble 1989; Chen, et al. 2012).

² Generally, TCM is safe when practiced by a licensed professional with genuine, uncontaminated medication; side effects, toxicity, and proper dosage of medically recognized TCM remedies have been established over centuries and can be found in official TCM texts (Bensky & Gamble 1989)

This text, the second substantial ancient Chinese medical record, was compiled during the North and South Kingdom Period (420–589 CE) by physician Tao Hongjing. It consists of an annotation of its predecessor, *The Divine Husbandman’s Classic of Materia Medica (Shen Nong Ben Cao Jing)*,³ as well as descriptions of 365 new medicinal substances not found in the *Husbandman’s Classic* (Zhao, et al. 2018). Since tiger bone was added centuries after the Han dynasty, it is reasonable to assume that while its use as a TCM remedy stems from ancient medical literature, tiger bone was not a founding part of the Chinese pharmacopeia.

As a result of numerous factors, including habitat loss and extensive poaching, tigers are classified as an endangered species, according to the International Union for the Conservation of Nature. Of the nine subspecies of tiger, only six are thought to be extant. The Amur Tiger (*P. t. altaica*), Northern Indochinese Tiger (*P. t. corbetti*), and Bengal Tiger (*P. t. tigris*) are all endangered, while the Malayan Tiger (*P. t. jacksoni*), Sumatran Tiger (*P. t. sumatrae*), and South China Tiger (*P. t. amoyensis*) are critically endangered.⁴ The other three subspecies, the Bali Tiger (*P. t. balica*), Javan Tiger (*P. t. sondaica*), and Caspian Tiger (*P. t. virgata*), have all been declared extinct since the mid-20th century (Goodrich, et al. 2015).

In China, tigers have had cosmological significance since ancient times. They have been thought to possess mystical powers as “representative[s] of heaven that could bring justice to the aggrieved, aid the righteous in times of need, or impose a reign of terror on wrongdoers” (Coggins 2004, 2). In Chinese folklore, the tiger’s presence is commonly associated with fluctuating economic, social, and political conditions. During times when the Mandate of Heaven⁵ was

³ Compiled between 200 and 250 CE

⁴ The South China Tiger has not yet been declared extinct; however, there have been no live wild specimens recorded in over 40 years.

⁵ Refers to the notion that Chinese imperial rulers had a divine right to rule, which was rescinded in the case of natural disasters or other turmoil believed to represent celestial wrath at a ruler’s incompetence or unworthiness

satisfied, tiger attacks occurred less frequently. These trends cemented the tiger's mythological importance (Coggins 2004).

Tigers, being large predators, require a copious amount of meat to survive. They usually kill large prey about once a week and eat 18–40 kilograms of meat off a carcass each day for up to six days, or until the carcass has been fully consumed (Nowell & Jackson 1996). Tigers rely on a consistent food supply and play a crucial role in their ecosystem, checking populations of large grazing animals, and therefore, preserving the health of the jungles and grassland they inhabit. Over time, tigers' ranges have diminished considerably. Previously, tiger populations had been widely distributed across Asia, into Southwest Asia and Russia. Today, tigers occupy less than 6% of their natural range (Sanderson, et al. 2006).

Although habitat loss was previously thought to be the primary cause of tigers' endangerment, poaching of tigers and their prey has proven to be “an imminent threat to the survival of the species” (Nowell 2000, vi). Killing tigers is not a new phenomenon in Asia. Independent of the influences of TCM or other native medicines, hunting tigers throughout their range has been occurring for centuries.

In India, the reputation of tigers as “man-eaters” dates back to the 17th century, and since then, tiger attacks⁶ have provided justification for killing tigers both in defense and for sport (Nowell & Jackson 1996). In China, the Mao-led Chinese Communist Party labeled the South China Tiger a “pest”, and ordered its extermination, which was almost completely successful by the end of the 1960's (Nowell 2000). Because of tigers' folkloric significance, their disappearance was seen as an augury of peace and prosperity; with the rise of Mao's leadership, the heavens no

⁶ Tigers typically attack humans to defend cubs, or when surprised by the presence of humans on their territory, and even then, they attack only after giving warning sounds and/or rushing the intruding human. Eating humans is a last resort for old or incapacitated tigers when they have lost the ability to hunt effectively for regular prey (Nowell & Jackson 1996).

longer needed to send tigers to keep equipoise on earth (Coggins 2004). After being hunted to near extinction, the remaining population of the South China Tiger was federally protected, but since then, the species has become critically endangered, and has not been sighted in the wild since the 1970's. After the 1980's, Chinese demand for tiger bones from other countries increased, presumably due to the lack of tigers that could be killed domestically. Tiger poaching in other parts of Asia escalated, and in 1993, the Chinese government banned the domestic trade of tiger bone, resulting in decreased consumption of tiger bone products in China. However, the presence and demand for tiger bone products has yet to be eliminated (Goodrich, et al. 2015). Presently, the black-market tiger trade is robust, fueled by both illegal hunting in the wild and intensive farming programs throughout Asia, including domestic facilities, billed as tourist attractions, which house upwards of 5000 tigers (Nowell 2007; Abbott & Kooten 2011).

Tigers bought and sold on the black market are used for multiple purposes: tiger bones are used for TCM, penises are used in aphrodisiacs, skin is sold as a luxury item, and live animals are sold as exotic pets. Between 2000 and 2015, 1755 trafficked tigers⁷ were confiscated by authorities in 801 separate seizures (Stoner, et al. 2016). This figure does not accurately reflect the total number of tigers globally smuggled during that time, since the majority of animal trafficking goes unnoticed by law enforcement.

Much of the tiger bone TCM products sold today are counterfeit. These misleading remedies contain very little tiger bone, or none altogether. Often, the crushed or powdered bones of bovines, bears, and other big cats serve as a replacement for tiger bone, and without the help of forensic testing, there is no way to discern whether or not a given medicine contains genuine tiger bone. This preponderance of fake tiger bone medicine may be, in part, beneficial to tigers, but it

⁷ The total global population of tigers during this time was around 3890 (Stoner, et al. 2016)

has also played a role in increasing consumers' demand for genuine tiger products (Nowell 2000). As of October 2018, the sale of tiger products is illegal, but the State Council of the People's Republic of China has authorized the use of tiger bones by qualified, state-registered practitioners of TCM (English.gov.cn 2018).

Setting aside protected areas across Asia would lessen the threat of habitat destruction; however, protecting tigers' habitat would not ensure their total safety. Because the illegal tiger trade is so well-established and widespread, the idea that government policy and wildlife stewardship programs alone will solve the issue of tiger poaching is unrealistic. In the case of tigers, trafficking will only come to a halt if demand for tiger-based TCM products is curbed across Asia. Non-medicinal tiger products have a much shorter history and weaker cultural influence in China, such that associated trafficking of these commodities account for a far smaller proportion of the overall issue (Nowell 2000). Reducing demand for tiger bone medication can be accomplished most efficaciously by finding and promoting viable alternatives, making tiger bone obsolete.

Fortunately, among the conditions tiger bone treats, none are life-threatening nor are they hard to treat using alternate means. In fact, there are tiger bone alternatives within TCM (see Table 1). *Acanthopanax* root bark (*Wu Jia Pi*) performs similarly to tiger bone; it also dispels wind and dampness in order to strengthen weak bones and sinews (Bensky & Gamble 1989) and ameliorate lower back and knee pain (Chen, et al. 2012). *Acanthopanax* root bark was recorded in *The Divine Husbandman's Classic of Materia Medica*, which makes it an older remedy than tiger bone. Additionally, it is native to China, and can be harvested in Hubei, Henan, Sichuan, Hunan, and Anhui (Bensky & Gamble 1989). Another alternative to tiger bone is *Pyrola* (*Lu Han Cao*), which also dispels wind-dampness and treats bone and tendon pain. *Pyrola* was first mentioned in Li Shi-

Zhen's *Materia Medica*,⁸ published in 1578 (Chen, et al. 2012). Both of these herbs are accessible to TCM practitioners, and are available for purchase online (Nuherbs 2019).

There is another option for those looking to directly replicate the effects of tiger bone without the help of plant-based remedies. Pig bones have long been noted as a slightly less effective equivalent to tiger bone (Chen, et al. 2012), which means there is nothing particularly exceptional about tiger bone, save for its high concentrations of calcium and collagen. There have been numerous cases recorded of synthetic tiger bone, enriched with calcium and collagen, used in place of tiger bone to improve the negative musculoskeletal side effects of aromatase inhibitors in women with breast cancer (Li, et al. 2017). Such synthetic tiger bone replacements would be cheap to produce and distribute on a large scale, at no cost to tigers.

Acanthopanax root bark, Pyrola, and synthetic tiger bone compounds are all viable and readily obtainable substitutes for tiger bone. If the Chinese government encouraged TCM practitioners and consumers to respectively discontinue prescribing and purchasing illegal tiger bone medicine in favor of any of these alternatives, then the demand for tiger bone, as well as the financial opportunity attached to tiger poaching, would significantly diminish, lessening the harmful impact of TCM and allowing tiger populations across Asia to stabilize.

Case Study 2: Pangolin

The second case study, the pangolin (family Manidae), is significantly more obscure than the tiger, yet its animal trafficking rates are the highest among all mammals. Pangolin meat is eaten in some parts of Asia and Africa (Actman 2017), but pangolins are primarily targeted for their scales, used in TCM to treat a variety of maladies. Pangolin scale (*Chuan Shan Jia*) is a salty and cool substance that promotes blood circulation, drains pus, stimulates lactation, and lessens

⁸ Also referred to as *Compendium of Materia Medica* (Zhao, et al. 2018).

swelling and stiffness (Bensky & Gamble 1989; Chen, et al. 2012). Largely believed to be miraculous cure-all, pangolin scale is also used in folk medicine to cure illnesses not mentioned in the TCM *Materia Medica*, including possession by devils and ogres, deafness, nervousness, malarial fever, and uncontrollable crying (“Chinese Medicine and the Pangolin” 1938). Like tiger bone, this remedy was discovered by Tao Hongjing; it first appeared in the *Miscellaneous Records of Famous Physicians (Ming Yi Za Zhu)* (Chen, et al. 2012).

Pangolins are anteaters native to Africa and Asia, notable for their keratinous scales, strong claws, and prehensile tails (“Pangolin” 2012). Of the eight species of pangolin, four are endemic to Africa, while the other four are native to Asia. According to the International Union for the Conservation of Nature, all four African pangolin species, the Black-bellied Pangolin (*Phataginus tetradactyla*), White-bellied Pangolin (*Phataginus tricuspis*), Giant Ground Pangolin (*Smutsia gigantea*), and Temminck's Ground Pangolin (*Smutsia temminckii*), are classified as vulnerable (Pietersen, et al. 2014; Waterman, et al. 2014a; 2014b; 2014c). Two of the four Asian pangolin species, the Indian Pangolin (*Manis crassicaudata*) and Philippine Pangolin (*Manis culionensis*), are endangered, and the other two, the Chinese Pangolin (*Manis pentadactyla*) and Sunda Pangolin (*Manis javanica*), are critically endangered (Baillie, et al. 2014; Challender, Baillie, et al. 2014; Challender, Nguyen, et al. 2014; Lagrada, et al. 2014).

Pangolins inhabit a wide variety of tropical and subtropical habitats, including rainforests, grasslands, dry forests, and tree plantations. The four Asian species of pangolin have a natural range that stretches from Southeast Asia (including the Philippines) to Pakistan, spanning India, Nepal, and southern China. The four African species are more densely distributed across Western, Eastern, and Southern Africa. All species of pangolin, across both Asia and Africa, are slow-breeding, solitary, mostly nocturnal insectivores. Pangolins use their long claws to rip into ant

nests and termite mounds and lay their tongues out to catch insects. Their thick skin and scales act as armor, protecting them from ant bites and stings.

Pangolins have a reputation for being elusive, which is surprisingly not an outcome of the recent spike in poaching. Described in 1871 as “not often seen even by the natives” (“The Pangolin” 1871, 142), pangolins remain shy, mysterious, and under-researched, while progressively becoming more imperiled by human action. They are crucial constituents of their ecosystem, preventing the overspread of colonial insects that would otherwise decimate plant life in the forests, grasslands, and plantations they inhabit (Challender, Waterman, et al. 2014).

Like tigers, pangolins also have spiritual significance in China. As a result of their strong connections to the earth, pangolins have long been viewed as deified protectors of the mountains they live on. According to local customs, hunters must perform an incantation to protect themselves from the pangolin before harvesting its meat or scales. These chants, used to neutralize a pangolin’s evil retributory spirit, must all include a deferential greeting to the pangolin, a declaration of the hunter’s intentions, and an explanation of why the hunter deserves to take the pangolin’s life (Coggins 2004). Still performed in pockets of China where pangolins remain, this long-held ritual demonstrates an intense spiritual connection between hunter and the pangolin, as well as a deep respect, lacking in the indiscriminate, industrial-scale pangolin poaching that occurs today.

Aside from their role in TCM, pangolins are also threatened by domestic bushmeat markets, electric fences, and traditional African medicine (Challender, Waterman, et al. 2014). Though TCM is the preeminent threat to pangolins across the globe, indigenous African medicine also plays a sizable role in diminishing local pangolin populations (Soewu & Ayodele 2009; Boakye, et al 2014).

Pangolins rely on their scales for protection against both animal and human predators. When threatened or startled, they roll into a ball, making it easy for poachers to collect and sell them. It has been illegal to trade Asian pangolins since 2000 (Challender, Waterman, et al. 2014), and in 2016, the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) banned trade of African pangolins as well, though many local governments do not have programs in place to actively expunge poaching efforts and enforce this ban (Actman 2017). Despite their internationally protected status, pangolins are hunted in Asia and Africa and traded in vast numbers to satisfy both local and international demands for meat and scales.⁹

The largest seizure of pangolin scales to date occurred in April 2019, when Singaporean authorities intercepted and confiscated an enormous 13-ton consignment of pangolin scales, shipped from Nigeria and destined for Vietnam. The value of this shipment was estimated at \$38.7 million USD (Singapore Government 2019). Though exorbitant, this sum indicates the value of only one shipment of pangolin scales, affording a narrow glimpse into the lucrative nature of the pangolin trafficking industry.

In Asia, pangolin scales are processed before being sold or administered to patients. Pangolin scales are most commonly fried, ashed, or roasted (“Chinese Medicine and the Pangolin” 1938), and can be taken in the form of a powder or decoction (Bensky & Gamble 1989; Chen, et al. 2012). These pangolin scale medicines are readily available and widely trusted, yet pangolin scales are made exclusively of keratin, the same material that makes up human hair and nails (Spearman 1967), and are devoid of any apparent miraculous properties.

Raising public awareness, establishing strict enforcement of international laws, and mobilizing local communities does help suppress poaching and trafficking of pangolins and their

⁹ Over one million individuals were thought to have been trafficked in the last 10 years (Challender, Waterman, et al. 2014)

scales, but in order to tackle the root of the pangolin's problem, it is necessary to find alternatives to pangolin scales (see Table 1). Vaccaria seed (*Wang Bu Liu Xing*), also known as cowherb seed or cow soapwort seed, is an ideal replacement for pangolin scales, as it also reduces swelling, disperses blood flow, promotes lactation, and drains abscesses. The discovery of vaccaria seed, first recorded in the *The Divine Husbandman's Classic of Materia Medica* (Bensky & Gamble 1989; Chen, et al. 2012), predates that of pangolin scale by at least 200 years. Vaccaria seed can be harvested in Jiangsu, Hebei, Henan, and Shaanxi (Bensky & Gamble 1989), or procured online (Nuherbs 2019).

Existing conservation programs, international trade bans, and public awareness, among other things, are all crucial to the pangolin's survival. However, the fate of the pangolin lies ultimately in the hands of the Chinese government, TCM practitioners and consumers. Pangolin scales have no value if there is no demand for them. A long-term, government-backed boycott of pangolin scales would result in a dramatically diminished market for pangolin scale, a loss of incentive for poachers and, most importantly, an opportunity for global pangolin populations to recuperate.

Case Study 3: Totoaba (& Vaquita)

The final case study, the totoaba (*Totoaba macdonaldi*), is perhaps the most obscure out of all animals addressed in this paper. Totoabas are an unassuming species of drum fish native to Mexico (NOAA Fisheries Office of Protected Resources 2012). They have no cultural or historical significance in Asia, yet their swim bladders, the organs used to regulate buoyancy, are consumed on a prodigious scale in China and Hong Kong, in the form of fish maw soup, an expensive delicacy thought to improve joint pain, circulation, pregnancy-related pain, and skin elasticity (Besessen 2018; Leung 2018). The newfound value of their swim bladders has exacerbated

existing patterns of overfishing in the area, and the vaquita (*Phocoena sinus*), the world's rarest cetacean, often ends up as bycatch (Valenzuela-Quiñonez, et al. 2011, Joyce 2016; Leung 2018). Prior to the decline in availability of Chinese bahaba (giant yellow croaker) swim bladders, there was no history of eating totoaba in China, nor an existing market for the fish (Bessesen 2018; Leung 2018). Totoaba is a new, completely invented remedy, to which no iteration of the TCM *Materia Medica* can lend credibility.

Both the totoaba and the vaquita are critically endangered, hovering on the margins of extinction (Findley 2010; Rojas-Bracho & Taylor 2017). They both have highly localized populations, concentrated in the Gulf of California,¹⁰ and suffer from illegal fishing and gill net entanglement, respectively. Totoabas are largely unknown to those not studying, fishing, or consuming them. They were classified as endangered in 1986, and have been critically endangered since 1991 (Findley 2010). Vaquitas, being the single most endangered marine mammals, are slightly more familiar. They were first listed by the IUCN as vulnerable in 1986, but by 1996, they were declared critically endangered (Rojas-Bracho & Taylor 2017).

Totoabas are the largest member of the Sciaenidae family. Like other drum fish, the totoaba is notable for its ability to produce sonorous vibrations during mating season (Bessesen 2018). Since adult totoabas have been known to reach a length of 2 meters (Findley 2010), they have previously been an attractive target for fisheries and sports fishermen alike. Commercial totoaba fishing started during the 1940's, when totoabas still inhabited the Gulf of California in large numbers, but eventually collapsed in the 1970's, due to reduced fish stocks (Findley 2010; NOAA Fisheries Office of Protected Resources 2012; Valenzuela-Quiñonez, et al. 2015). These totoaba fisheries provided the economic foundation on which communities in the area were built

¹⁰ Otherwise known as the Sea of Cortez

(Valenzuela-Quiñonez, et al. 2015, Bessesen 2018;), and in the absence of legal totoaba fishing opportunities, poaching has become an enticing way to bring in extra income. One totoaba swim bladder alone is worth over \$14,000 on the black market (Joyce 2016; Wade 2017), making it equally valuable as cocaine. Especially large swim bladders have been sold at \$250,000 (Bessesen 2018). If current fishing patterns continue, the totoaba will soon become extinct.

Currently, poaching and habitat degradation are the primary factors threatening totoabas' survival. It has been illegal to fish for totoaba since 1975 (Findley 2010), but the remunerative overseas market still incentivizes local fishermen to leave gillnets out, in the hopes of harvesting a swim bladder (Findley 2010; Valenzuela-Quiñonez, et al. 2011). There are other species of fish in the Gulf of California that are legal to harvest, and much of the illicit totoaba poaching is committed under the guise of legal fishing (Bessesen 2018).

Totoabas are also threatened by the changing composition of their nursery waters. Young totoaba are born in the formerly brackish Colorado River Delta, and they move down the Gulf of California as they mature. This transition occurs a result of the juvenile totoabas' preference for low-salinity environments. However, since the Hoover Dam was built, much of the Colorado River's fresh water gets diverted away from the Gulf of California. This has significantly altered the totoaba spawning cycle (NOAA Fisheries Office of Protected Resources 2012; Valenzuela-Quiñonez, et al. 2015). Evidence from totoaba otoliths (ear bones) indicate that totoabas now spend considerably more time maturing in the Colorado River Delta and grow to only half the size of their pre-dam counterparts (Wade 2017).

The vaquita is a small porpoise that inhabits shallow waters and feeds on fish, crustaceans, and squid (Rojas-Bracho & Taylor 2017). Vaquitas themselves have never been the target of fishermen, but their fate has always been tied to totoaba fishing. The switch from small-scale hook-

and-line fishing to commercial gillnet fishing in the late 1940's proved to be the advent of both species' devastation. Like other cetaceans, vaquitas must surface for air every few minutes. When they get ensnared in gillnets intended for totoabas or other fish, vaquitas panic and thrash, which eventually leads to suffocation. Their bodies are usually found hours later, when fishermen come back to check on their nets, and their deaths are not consistently reported, due to the potential repercussions of killing a critically endangered animal, even by accident. Despite the termination of commercial totoaba fishing efforts in the 1970's, vaquita entanglement has persisted, if not worsened. Gillnets are still used en masse to catch totoaba and other fish, and unmanned "ghost nets" left out in the water are equally hazardous (Bessesen 2018).

Over the past 60 years (approximately three generations), vaquita populations have seen a 95% decrease (Rojas-Bracho & Taylor 2017), with a 34% rate of decline per year between 2011 and 2015 (Taylor, et al. 2016). The current vaquita population is unknown, as vaquita births and deaths are not comprehensively recorded, but estimates place the total number of living vaquitas at around 10 or fewer (Leung 2019).

The Mexican government has repeatedly sought to initiate total gillnet bans and introduce alternative fishing gear, looking to mimic the success of TEDs (turtle excluder devices), which allow turtles to pass through shrimp nets without getting enmeshed (IUCN 2016). Unfortunately, these policies have faced staunch opposition from local fishermen, whose incomes are substantial improved¹¹ with the sale of a totoaba swim bladder.

Though the extinction of the totoaba seems inevitable at this point, a complete cessation of totoaba poaching could allow populations to rebound to levels sufficient to ensure its future existence. A successful boycott on fish maw soup in China and Hong Kong would mitigate the

¹¹ In Mexico, one pound of shrimp goes for \$9, while a pound of totoaba swim bladder is worth \$4000 (Bessesen 2018)

high demand for totoaba swim bladder and take some of the stress off the remaining totoaba population. In order to reduce demand for totoaba swim bladder, consumers would need to use other substances to achieve the same results. Because totoaba is not recognized by official TCM texts, it is difficult to suggest exact replacements.

The following table consolidates all remedies mentioned in this paper, their medicinal uses, and plant-based alternatives within TCM.

Table 1: Animal-based remedies and their alternatives

Animal Product	Use	Alternative(s)
Tiger Bone	Improves joint pain, bone and muscle weakness	Acanthopanax root bark, Pyrola
Pangolin Scale	Promotes circulation, lactation, lessens swelling	Vaccaria seed

Conclusion

Today, TCM is in a position of substantial influence. Support from the Chinese Communist Party has revived TCM and made it nearly invincible, while the burgeoning middle class in China and other parts of Asia has developed a tremendous appetite for expensive animal-based miracle drugs that are more status symbol than they are effective medication. These two factors have engendered a monumental surge in animal poaching and trafficking around the globe, pushing some species hazardously close to extinction. The current black-market trade of exotic animal parts threatens not only individual species, but also the overall health of their ecosystems. Many species hunted for TCM, including the ones represented in this paper, are fundamental to the biodiversity and well-being of their environment.

Conservation activists have been instrumental in educating the public and establishing in-situ anti-poaching efforts, but they have been unable to confront the crux of the issue: the overseas demand for illegal TCM remedies. It is necessary to reform regulations and common practices of TCM, so that poaching, smuggling, and selling endangered animal parts are no longer profitable activities. In order to do so, the Chinese Communist Party must be actively involved in building domestic awareness around conservation, establishing (and stringently enforcing) policies that protect endangered animals, and denouncing the use of illegal animal products in TCM. TCM practitioners have a secondary role in shaping public perceptions and promoting animal product substitutes.

Now more than ever, conservation biology and the related study of anthropogenic impacts on our planet must be prioritized, as the window for reversing our damage draws increasingly shorter. Further study of contemporary TCM trends, as well as a larger body of research concerning the pangolin, totoaba, and vaquita are necessary in order to continue protecting these unfamiliar and highly imperiled species.

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