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REVIEW AND SYNTHESIS

Understanding Traditional Chinese Medicine to strengthen conservation outcomes

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Abstract

1. Numerous treatments in Traditional Chinese Medicine (TCM) involve the use of wildlife products, including some that utilize ingredients derived from endangered flora and fauna. Demand for such endangered wildlife products in TCM can threaten the survival of species and pose serious challenges for conservation.
2. Chinese medical practice is embedded in the cultural fabric of many societies in East and Southeast Asia, and remains an integral part of everyday life and knowledge. It is grounded in principles and theories that have grown over hundreds of years and differ substantially from those of mainstream allopathic biomedicine.
3. In order to address the threats posed by the medicinal consumption of endangered wildlife, conservation scientists and practitioners will benefit from a basic understanding of TCM. Such knowledge will enable conservationists to craft culturally nuanced solutions and to engage constructively with TCM stakeholders. However, conservationists typically lack familiarity with TCM as the incompatibility of many TCM concepts with those of the biomedical sciences poses a barrier to understanding.
4. In this paper, we examine the core theories and practices of TCM in order to make TCM more accessible to conservation scientists and practitioners. A better understanding of TCM will enable conservationists to deliver more effective and lasting conservation outcomes.

KEYWORDS

consumptive use, culturally sensitive solutions, endangered species, medicinal product, TCM, wildlife trade

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1 | INTRODUCTION

The consumptive use of wildlife is often rooted in traditional beliefs and customs (Thomas-Walters et al., 2020). Many people around the world rely on traditional forms of medicine for their health and well-being. These diverse medical systems make use of an array of wild plants, animals and fungi, often ones that are locally available and that are not threatened. However, some traditional medical systems make use of products derived from endangered species, including Traditional Chinese Medicine (TCM; Hamilton, 2004; Liu et al., 2016; Zhang & Yin, 2014). Demand for products derived from endangered species, which range from rhinoceros horn (Traditional Chinese/Simplified Chinese/Chinese pinyin: 犀牛角/犀牛角/*xī niú jiǎo*; relevant/affected taxa: extant Rhinocerotidae; Biggs et al., 2013) to caterpillar fungi (冬蟲夏草/冬虫夏草/*dōng chóng xià cǎo*; *Ophiocordyceps sinensis*; Hopping et al., 2018), contributes significantly to the threats facing many species today (Maxwell et al., 2016).

An understanding of the cultural roots and drivers of wildlife consumption will enable the development of more culturally nuanced strategies to manage the threat from wildlife trade. Yet at present, conservation scientists and practitioners typically lack familiarity with TCM, and engagement with TCM stakeholders is limited (Cheung et al., 2018; Liu et al., 2016). As is the case with other forms of complementary and alternative medicine (e.g. naturopathy, homeopathy, chiropractic), concepts in TCM can be incompatible with biomedical science. This presents a barrier to understanding TCM and limits the ability of conservationists to consider TCM perspectives in decision-making. A lack of understanding can render conservation efforts counterproductive if crucial stakeholders are neglected or alienated (Margulies et al., 2019; Swan & Conrad, 2014).

Traditional Chinese Medicine is considered within its community to be an internally consistent body of knowledge with systematized practices, even though not all aspects of TCM may be readily confirmed or refuted using Popperian deductive methods. For users of TCM, its long history of accrued experience and writings is indicative of its efficacy (Chung et al., 2014; Spence & Li, 2013). Cases of active ingredients being isolated and developed into biomedical pharmaceuticals are cited by some as proof of TCM's validity, like the use of artemisinin extracted from sweet wormwood (青蒿/青蒿/*qīng hāo*; *Artemisia annua* L.) in malaria treatments (Hsu, 2018; Su & Miller, 2015).

Traditional Chinese Medicine remains embedded in the cultural fabric of ethnic Chinese societies, including immigrant communities abroad (Kong & Hsieh, 2012). Many other forms of traditional medicine across East and Southeast Asia are closely related to Chinese medical learning (Park et al., 2012), which continue to shape norms and social representations of health and illness (Gervais & Jovchelovitch, 1998). Attempting to transform these views and values for the purposes of biodiversity conservation can be difficult, and may risk charges of insensitivity, cultural imperialism or even racism (Manfredo, Bruskotter, et al., 2017; Margulies et al., 2019; St. John et al., 2018). The challenge for conservation is to build a stronger understanding of TCM and engage with TCM stakeholders to ensure that interventions are culturally appropriate and socially compatible. This requires that TCM is approached with an open mind.

The aim of this paper is to make TCM more accessible to conservation scientists and practitioners. To do so, we examine its core theories and practices, before discussing how TCM and conservation could interact more constructively in the future. This review is, admittedly, not exhaustive, yet nevertheless aims to present a balanced perspective that we believe will be of benefit to biodiversity. A clearer understanding of TCM will enable conservationists to develop more culturally nuanced policies and management.

2 | STARTING WITH AN OPEN MIND: A CONSERVATIONIST'S GUIDE TO TCM

In this section, we discuss a number of key TCM concepts to enable conservationists to develop greater familiarity with TCM. We illustrate TCM concepts with the use of examples, drawing mostly on endangered species products that have attracted particular conservation interest. This emphasis should not be interpreted as a reflection of the diversity of medicinal ingredients used in TCM, the majority of which are plants that are not threatened. The authors are neither promoting nor discouraging the practice of TCM, and this paper does not adjudicate upon the effectiveness of TCM treatments that utilize endangered species. Neither do we weigh the costs of ecological problems associated with TCM (e.g. use of endangered species products) against those of biomedicine (e.g. antibiotic contamination of soil and water resources, or the use of horseshoe crab blood in vaccine production). We encourage those seeking further depth or clarity on TCM to explore the primary research and TCM resources cited (we highlight Kaptchuk, 2000; Sivin, 1987; Xu et al., 2018 as key sources of factual TCM knowledge in this paper).

2.1 | Breaking down barriers

2.1.1 | Definitions, definitions …

To begin exploring TCM, we first examine how the term itself has evolved. For centuries, geographic, climatic and cultural differences produced varied medical practices across China (Pan et al., 2014). In the 19th century, Christian missionaries began teaching Western practices, leading 'Western medicine' (西醫/西医/*xī yī*) to be distinguished from 'Chinese medicine' (中醫/中医/*zhōng yī*). There were many efforts in the early 20th century to combine and integrate the many variants of 'Chinese medicine', but it took until the 1950s for them to be implemented in a standardized way in the newly founded People's Republic of China under the umbrella term 'Traditional Chinese Medicine'. A vast commercial industry has developed around TCM in the last three decades (Xu & Yang, 2009), and the emergent 'Chinese medicine and pharma-industrial complex' (中醫藥/中医药/*zhōng yī yaō*) aims for scientific legitimization (Hsu, in press). Regardless of etymological specificities, official Chinese

sources use 'TCM' to refer to the terminological variants *zhōng yī* and *zhōng yī yaō* interchangeably.

For the purposes of this paper, our use of 'TCM' is in keeping with both current official Chinese sources and the common usage of the term in conservation circles, encompassing the wider 'Chinese medicine and the pharma-industrial complex' within and beyond China's borders. We do not include other traditional medicines that may trace their origins to ancient China, including Japanese Kampo, traditional Korean medicine and traditional Vietnamese medicine. Although substantial overlaps persist due to common ancestry, significant differences exist (Cha et al., 2007; Park et al., 2012). Readers should refer to the World Health Organization's standardized definitions for greater precision (World Health Organization, 2007). We use 'biomedicine' to describe the allopathic, scientific evidence-based medicine that is in mainstream use in the West.

2.1.2 | TCM and biomedicine

Despite differences in methods, both TCM practitioners and biomedical physicians work to improve their patients' health. In TCM, health is understood to be a dynamic state of balance (Kaptchuk, 2000; Stevenson et al., 2009). Good health comes from 'balance' and 'harmony'; imbalances give rise to illness. Traditional Chinese Medicine practitioners aim to address imbalances that have yet to manifest as illness by modifying lifestyle habits. Once illness manifests, TCM practitioners draw on the patient's symptoms and complaints to identify patterns of disharmony in order to prescribe treatments that restore holistic balance (Kaptchuk, 2000; Sivin, 1987; Xu et al., 2018).

Traditional Chinese Medicine users perceive biomedicine to be powerful and fast-acting, whereas TCM works slowly and steadily (Chung et al., 2014). Hong Kong's ethnic Chinese consider TCM to be good for minor illnesses but inadequate against serious illnesses (Lam, 2001). Many see TCM as delivering more personalized care, better at addressing the root causes of disorders, and 'easier on the body' with fewer side effects (Chung et al., 2014). For serious illnesses, TCM can complement biomedicine by 'cutting the tail of the illness' and 'clearing the root of the disease' (Chung et al., 2014; Koh, 2010; Lam, 2001). In China, integrating biomedicine and TCM is seen to have synergistic advantages, particularly for chronic or serious disorders, and so patients with serious or even terminal diseases like cancer receive TCM alongside biomedical treatment (Chung et al., 2014; Harmsworth & Lewith, 2001). However, such integration is not universally accepted. Some observers remark that this may turn TCM into a complementary treatment, reducing its broad remit to just manage side effects (Chung et al., 2014; Harmsworth & Lewith, 2001). Singapore endorses strict separation (Smith, 2018a), where TCM has been somewhat marginalized because of concerns from biomedical professionals over the possibility of unintended drug interactions. Consequently, patients tend to withhold information on TCM use from their biomedical physicians for fear of disapproval (Chang & Basnyat, 2015; Lim et al., 2005).

Research has found that trust in TCM's efficacy is not necessarily based on biomedical evidence (Chung et al., 2014). Although cornerstones of biomedicine (including concepts of biochemistry, anatomy, physiology and pathology) only partially overlap with TCM, and concerns have been raised over treatment effectiveness and pharmaceutical safety (Critchley et al., 2000; Leung et al., 2005; Williamson et al., 2013), TCM is not necessarily incompatible with the scientific method. Traditional Chinese Medicine makes greater use of analogical over analytical thinking, and has fine-tuned its methods of establishing complex treatment procedures (Kaptchuk, 2000). There are numerous documented testimonials of TCM treatments effecting desirable medical outcomes. This has led some to question the criteria for 'evidence-based' medicine more broadly (Scheid & MacPherson, 2011). Broader consideration of what constitutes medical evidence may be required, as the TCM community values the knowledge accrued through millennia of medical practice alongside biomedical evidence (Chung et al., 2014; Liu et al., 2011; Spence & Li, 2013).

The perception that TCM is scientifically backward sometimes leads to indignation at its continued use or contempt for its philosophies among conservationists (Swan & Conrad, 2014). However, the notion that only Western science is science and that only biomedicine is evidence-based may not be the best starting point for bridging cultural divides to achieve conservation goals (Biggs et al., 2017). Conservationists may have more success, therefore, if they approach TCM with an open mind (Figure 1), beginning with acknowledging that TCM builds on forms of evidence that resonate with TCM users.

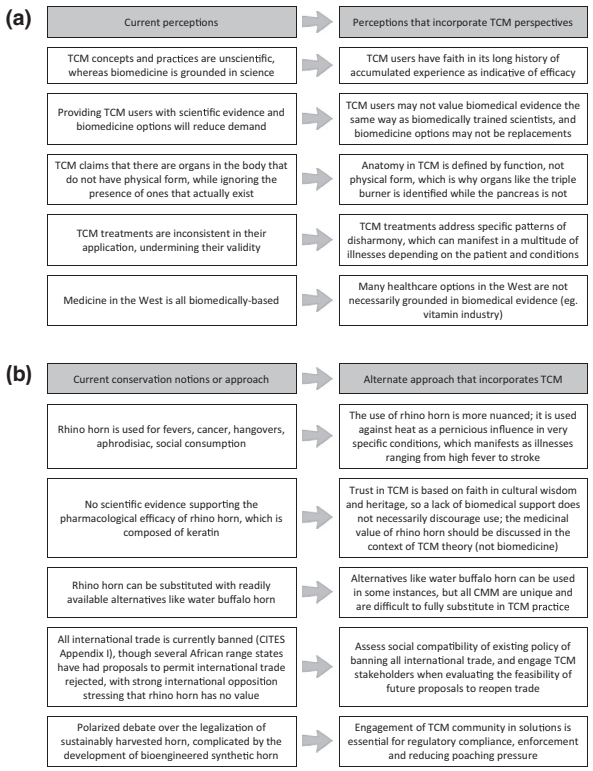

FIGURE 1 (a) Common perceptions of Traditional Chinese Medicine (TCM) and alternate perceptions that consider the perspective of TCM stakeholders in order to break down barriers, and (b) how TCM can be better incorporated into conservation, using rhino horn as an example

2.2 | Foundations of TCM

2.2.1 | Development of TCM

The oldest texts on Chinese medical learning date back over 2,000 years, and although TCM has developed significantly since, aspects of present-day practice remain consistent with some of its early tenets (Hsu, 2001; Xu & Yang, 2009). For much of its history, TCM was typically practiced in small clinics (not uncommonly located in the practitioner's home), and very few doctors had any Western biomedical knowledge (Karchmer, 2010). No formal TCM training existed, and knowledge and skills were generally transferred from family member to family member, through apprenticeships and through written texts (Xu & Yang, 2009). Yet since the 1950s, TCM practitioners have increasingly been trained in formal medical or pharmacy programs, which are now taught in universities and other educational institutions (Xu & Yang, 2009). As such, the development of concepts and methods in TCM has traditionally been practice-driven, occurring through the documentation and transmission of collectively accrued clinical experience (Liu et al., 2011). While such processes of cultural learning and adaptation can indeed produce beliefs and practices that can have a legitimate basis, errors and biases can also emerge and be propagated (Henrich & Henrich, 2010). Indeed, stakeholders within the TCM community today have therefore increasingly recognized the value of applying modern scientific methods and norms in modernizing the development of TCM (Liu et al., 2011; Zhou, 2009).

2.2.2 | Balance and harmony

Traditional Chinese Medicine was founded on the idea that all natural phenomena can be described as being *yin yang* (陰陽/阴阳/*yīn yáng*)—a duality of complementary forces—and correspond to the five phases (五行/五行/*wǔ xíng*; wood, fire, earth, metal and water) that effect changes and movements. 'Well-being' is understood to come from both an internal balance of the body and an external harmony with social and natural surroundings. *Yin yang's* interdependence is central to this balance. For instance, illnesses characterized by weakness, slowness, coldness and underactivity are relatively more *yin*; those manifesting strength, forceful movements, heat and over-activity are relatively more *yang*. Every *yin yang* classification can be infinitely bisected, because within *yin* are characteristics that are more *yang* and vice-versa. For example, *yin* illnesses characterized by coldness may exhibit *yang* aspects like sudden convulsions. *Yin* and *yang* are not static, but change in accordance with surrounding conditions. This ever-shifting balance is what determines a person's health and wellbeing.

Traditional Chinese Medicine treatments, including those that include the consumption of endangered wildlife products, aim to restore and maintain balance. For example, *yin* depletion is treated by nourishing *yin*. The common Anemarrhena plant's rhizome (知母/知母/*zhī mǔ*; *Anemarrhena asphodeloides*) and Reeve's turtle shells (龜板/龟板/*guī bǎn*; *Mauremys reevesii*) both nourish *yin*, but the conditions for which they can be used are different (Hijikata et al., 2006; Xie & Du, 2011). This is because the unique properties of each medicinal ingredient limit its applicability to specific patterns of disharmony, which are imbalances specific to the patient as a whole person (Jiang et al., 2012).

Traditional Chinese Medicine emphasizes continually reinforcing balance even when in good health. *Yangsheng* (養生/养生/*yang shēng*, nurturing life) is practiced to make small adjustments to maintain balance (Koh, 2010; Wilms, 2010), and medical treatment is only resorted to when less drastic measures cannot address disharmony (Liu et al., 2013). Thus, the consumption of medicinal ingredients is not always of immediate medical necessity, as some are consumed as food or tonics to boost overall health (Chau & Wu, 2006; Koo, 1984; Smith, 2018a). For example, tiger bone (虎骨/虎骨/*hǔ gǔ*; *Panthera tigris*) is used in the treatment of rheumatic pains, but is also prepared into wine and drunk to strengthen bones (Bensky et al., 2004; Gratwicke et al., 2008; Wong, 2016).

2.2.3 | The five organs and the five seasons

Whereas biomedical anatomy is determined by physical organs and systems, anatomy in TCM revolves around functions. As such, there are organs in TCM with no anatomical equivalent in biomedicine (e.g. triple burner), and others in biomedicine that are not distinguished in TCM (e.g. pancreas; Kaptchuk, 2000). Traditional Chinese Medicine recognizes five *zang* (臟/脏/*zàng*; repositories/depots, viscera) and six *fu* (腑/腑/*fǔ*; halls/palaces, bowels), each with seasonal vulnerabilities. The five *zang* organs are the liver, heart, spleen, lungs and kidneys. They are 'deeper' in the body than the *fu* bowels, with distinct functions that only partially correspond with their equivalently named organs in biomedicine. These five organs tend to serve as repositories for 'substances' like *qi* (Kaptchuk, 2000; Xu et al., 2018). The six *fu* bowels make up the outer aspects of their corresponding *zang* repositories (spleen and stomach; liver and gall bladder; heart and small intestine; lungs and large intestine; kidneys and bladder; and in some circumstances pericardium and triple burner), and are involved with nutrient absorption, bowel movement and excretion. Each *zang* and *fu* pairing is connected to the others through a network of twelve 'meridians' or, rather, 'channels' (經絡/经络/*jīng luò*). These are not only important for TCM practitioners in their provision of treatments, but conservationists could benefit from knowing that each of these has a special affinity for receiving different plant-, animal- and mineral-based medicinal substances (Kaptchuk, 2000; Xu et al., 2018).

Qi (氣/气/*qì*) and *xue* (血/血/*xuè*) are stored in each of the *zang* repositories, with the upper part of the body in the heart-lung region known for being filled with *qi* and the liver in the lower part of the body for storing *xue*. *Qi* is often translated as 'vital energy', but is more complex than this translation suggests. Everything in the universe is defined by its *qi*, which rises in spring when everything sprouts and retreats in autumn as do plants and animals

(Kaptchuk, 2000; Xu et al., 2018). *Xue* also has a broader definition in TCM than blood as defined in biomedicine, and is a circulating substance that nourishes, maintains and moistens the body. *Xue* is generally *yin*—responsive, softening and nurturing—whereas *qi* is *yang*— dynamic and transforming. *Qi* and *xue* are inseparable and mutually dependent: *qi* creates and moves *xue* through the body, while *xue* nourishes the organs that regulate *qi* (Kaptchuk, 2000; Xu et al., 2018). In addition to *qi* and *xue*, *jing* (精/精/*jīng*, essence), *shen* (神/神/*shén*, spirit) and *jinye* (津液/津液/*jīn yè*, fluids) are considered to be bodily 'substances' (Kaptchuk, 2000; Xu et al., 2018). Medicinal ingredients can have properties that target imbalances in the flows and transformative fluxes of these 'substances'. For instance, pangolin scales (穿山甲/穿山甲/*chuān shān jiǎ*; *Manis*, *Smutsia* & *Phataginus* spp.) disperse blood stasis (瘀血/瘀血/*yū xuè*, blood pooling, e.g. haematoma) and reduce swelling in toxic sores by enlivening and promoting blood circulation (Bensky et al., 2004; Song et al., 2017; Zhu et al., 2015).

2.3 | Diagnosing and treating disharmony

Personal characteristics like gender and age affect susceptibility to certain imbalances (Scheid, 2008; Zhang, 2007). Illness can arise from endogenous imbalances, including lifestyle influences like diet and emotional state, as well as from disharmonies of external origin. The way in which exogenous imbalances are conceptualized has evolved over time, and earlier conceptual frameworks (e.g. six warps, 六經/六经/*liù jīng*) remain influential today in devising prescriptions of herbal decoctions (Kaptchuk, 2000; Xu et al., 2018). In more modern practice, practitioners have developed a related system of thought, wherein disorders are seen to penetrate the body in four sequential levels (四分/四分/sì fēn): (a) beginning at the surface *wei* (衛/卫/*wèi*; outer defenses) level, (b) next affecting the *qi* level, (c) then the *ying* (營/营/*yíng*; maintenance) level, and (d) finally attacking the deepest level, the *xue* level (Hanson, 2011; Xu et al., 2018). The deeper a disorder penetrates in the body, the more serious it becomes and more difficult it is to treat.

The concept of cold damage evolved to encompass six exogenous illness factors (六淫/六淫/*liù yín*) which arise from an excess of wind, cold, dampness/humidness, heat/fire, dryness and summer heat (Dashtdar et al., 2016). These disrupt the delicate balance of health, and treatments address imbalances provoked by these pernicious influences. For instance, the cooling properties of saiga antelope horn (羚羊角/羚羊角/*líng yang jiǎo*; *Saiga tatarica*) may be appropriate for heat-related imbalances, particularly those of the liver channel (Bensky et al., 2004; Doughty et al., 2019). These exogenous factors are not causal instruments in the biomedical sense of pathology (i.e. influenza virus causes the flu). Rather, they are a means for TCM practitioners to discern patterns of disharmony. To identify these patterns, information on the patient's complaints and constitution are gathered using four traditional examination methods (四診/四诊/*sì zhěn*): visual observation, listening and smelling, questioning and pulse diagnosis. Practitioners consolidate the information through *bianzheng* (辨證/辨证/*biàn zhèng*; distinguishing patterns, syndrome differentiation) to diagnose specific patterns of disharmony (Karchmer, 2010). These patterns are not diseases in the biomedical sense, as they can differ from one day to another and transform into another pattern. Vice versa, the same pattern can account for different complaints in different patients (Smith, 2018a).

Traditional Chinese Medicine practitioners select treatments for their patients through *lunzhi* (論治/论治/*lùn zhì*; Jiang et al., 2012). TCM treatments are diverse, and include pharmacotherapy, acupuncture, moxibustion, therapeutic massage, food therapy and physical exercises (Critchley et al., 2000; Griffiths et al., 2010). Viewing illness as the manifestation of patterned disharmony, a single type of TCM treatment is able to cure different biomedically defined diseases (Kaptchuk, 2000). Liver fibrosis, biliary cirrhosis and liver cancer are treated very differently in biomedicine, but TCM patent medicines containing bear bile (熊膽/熊胆/*xióng dǎn*; mostly *Ursus thibetanus*, some *Ursus arctos*; gallbladder traditionally used) have been used to reduce liver fire and heat for all three illnesses (Li et al., 2016). This is also why different treatment strategies in TCM are used to treat the same disease. For a sore arising from excessive fire, a patient might be prescribed a heat-dispelling herbal decoction or given acupuncture at precise points that cool fire (Kaptchuk, 2000).

3 | A BETTER UNDERSTANDING OF TCM: IMPLICATIONS FOR CONSERVATION

Pharmacotherapy is the aspect of TCM with the greatest conservation implications, wherein Chinese *materia medica* (CMM)—medicinal ingredients derived from plants, animals and minerals—are prepared and consumed. Plants have always dominated the types of CMM that are used in TCM. For instance, the authoritative 16th century text called *Bencao gangmu* (本草綱目/本草纲目/*běn cǎo gang mù*; Systematized Compendium of Materia Medica) listed a total of 1,895 entries, of which 1,094 were plants (Métailié, 2001). This continues to be the case today: of over 10,000 documented CMM, the vast majority of CMM are plants—only 12% are of animal origin and even fewer are minerals (Liu et al., 2016). Although the total number of CMM that have been documented is quite large, only around 1,000 of these are commonly used in TCM practice today (Liu et al., 2009; Williamson et al., 2013).

Pharmacotherapy is built on the understanding that each CMM imparts unique medicinal properties that can rectify specific imbalances. Ingredients with seemingly similar functions might be used very differently because of nuances in their properties. For example, both bear bile and rhino horn are cold in nature and dispel heat, but target different organs and channels: rhino horn targets heat imbalances in the liver and kidney systems, while bear bile targets the gall bladder, liver and heart organ systems (Bensky et al., 2004). For the most part, CMM are prepared and consumed in combination with other ingredients in multi-herb

formulae (Yi & Chang, 2004). When prescribing these decoctions, TCM practitioners exercise flexibility to combine CMM with different properties to impart an intended treatment effect. To individualize treatments, practitioners adjust dosages and substitute ingredients in traditional formulae based on the patient's diagnosis, personal constitution, CMM availability and affordability (Xu et al., 2018).

3.1 | Sustainability, conservation and TCM

Demand for the consumptive use of wildlife products is where TCM and biodiversity conservation intersect, because certain CMM are derived from endangered or CITES-listed species (Table 1), including plants like the tall Gastrodia tuber (天麻/天麻/*tiān má*; *Gastrodia elata*; Subedi et al., 2013) and charismatic megafauna like tigers and rhinos. Growth in the TCM sector itself can present challenges for species that are overexploited, particularly due to the expanding scale of demand and consumption both domestically and abroad. Furthermore, TCM is not a static system, and is continuously evolving as a medical system and developing as a commercial industry. As a result, the types of CMM that are used and how these are applied change over time, and threats to species can emerge or be exacerbated (Hinsley et al., 2020; Zhang et al., 2018). For instance, the increased use of *Rhodiola* (紅景天/红景天/*hóng jǐng tiān*; *Rhodiola* spp.) in TCM—particularly in patented herbal products—over the past several decades have contributed to growing market demand and subsequent pressure on species from unmanaged commercial exploitation of wild stocks (Cunningham et al., 2020). For some species, wild exploitation at the rates required to meet market demand is simply not sustainable because of biological factors (e.g. low reproductive rate, slow growth, endemic, climate change sensitive), and alternative solutions need to be found.

Substitution can be a viable solution in certain cases, as practitioners often adjust and substitute CMM in prescriptions with other varieties of the plant or animal, or other species entirely. For instance, the pharmacological activity of ginseng (人參/人参, *rén shēn*; *Panax* spp.) leaf-stems is comparable to that of its roots and can be harvested without uprooting the plant, making it a more sustainable alternative (Chen et al., 2016; Wang et al., 2009). Products derived from other plants have also been used as substitutes for ginseng, such as *dangshen* (黨參/党参/*dǎng shēn*; *Codonopsis pilosula*; Shergis et al., 2015). Substitution with artificial or synthetic alternatives is also a solution that is being explored for some high-priced products like rhino horn (Chen, 2017). Although the belief that wild-harvested CMM are more effective than alternatively sourced CMM remains prevalent and continues to be reinforced by TCM practitioners (Liu et al., 2016 #1071), synthetics remain a promising solution where applicable, given the acceptance of products like synthetic bear bile among Chinese consumers (Davis et al., 2016). Conservationists can engage proactively with TCM stakeholders to explore the potential of substitution in addressing the use of species that are endangered. Research has shown that species conservation awareness can increase the intended willingness of consumers to accept substitutions for medicinal products that are normally derived from wild animals, which could drive social marketing and stakeholder engagement efforts in the future (Liu et al., 2016). Further, in a behaviour change intervention in Singapore, saiga horn consumers learning about the saiga's conservation status through news promotions commonly responded by asking about or sharing CMM substitutes (Doughty et al., 2020).

However, substitution is not universally applicable. For instance, removing rhino horn from the arsenal of Chinese *materia medica* and encouraging its substitution with highly abundant water buffalo horn (水牛角/水牛角/*shuǐ niú jiǎo*; *Bubalus bubalis*) has not eliminated medicinal demand and subsequent rhino poaching, with consumers continuing to see medicinal value in rhino horn (Cheung et al., 2018; Hanley et al., 2018). Additionally, a concept in TCM whereby certain ingredients produced in specific locales are considered superior in quality and clinical effectiveness (道地藥材/道地药材/*dào dì yào cái*)—similar to that of terroir in viticulture—further complicates substitutability (Yang et al., 2018).

Cultivation and breeding have the potential to ease pressure from wild-harvesting if it is financially competitive (Chen et al., 2016; Larsen & Olsen, 2007; Phelps et al., 2014). Around 80% of CMM are plant-derived, the majority of which are wild-harvested (Kling, 2016), with fewer than 300 species cultivated (Chen et al., 2014). For species that are overexploited in the wild, exploring the potential of cultivation and sustainable production is critical for conservation (Challender & MacMillan, 2014; Chen et al., 2016). For instance, efforts to artificially cultivate the caterpillar fungi have been ongoing for many decades, but the techniques to do so on an industrial scale have only recently been developed (Li et al., 2019). Investing in research to develop methods of cultivating other medicinal ingredients that are similarly derived from endangered species may help alleviate pressure on wild populations from human demand.

While adopting measures to improve production sustainability are positive steps, including the Chinese government's promotion of agricultural best practices in medicinal plant cultivation (Chen et al., 2016), cultivation is also not a universal solution. For some CMM, including tendrilleaf fritillary bulbs (川貝母/川贝母/*chuān bèi mǔ*; *Fritillaria* spp.) and Paris rhizomes (重樓/重楼/*chóng lóu*; *Paris polyphylla*), cultivated yields are unable to meet demand, and significant quantities remain wild-harvested despite protection (Cunningham, Brinckmann, Bi, et al., 2018; Cunningham, Brinckmann, Pei, et al., 2018). In addition to the loss of livelihoods for wild-harvesters, cultivation is also associated with a number of other challenges, including long lead times before harvesting, concerns over pharmacological efficacy and problems associated with pesticide use (Kling, 2016; Leung et al., 2005).

3.2 | Diversity and pluralism

In Chinese and Chinese-influenced societies, TCM is not just medicine, but an inextricable part of culture and daily life that influences

TABLE 1 Some examples of Traditional Chinese Medicine (TCM) products derived from globally threatened species[a], including examples described in text. This is not a comprehensive resource of all TCM ingredients derived from threatened species, and a formal analysis of this nature is a priority for future research. The examples in this table were compiled to illustrate the taxonomic diversity of medicinal ingredients used in TCM, which are derived from animals, plants and fungi. While the majority of wildlife products used in TCM come from plants that have not had their conservation status formally assessed, the use of endangered species products is a major conservation challenge

Ingredient name					
English	Pharmaceutical	Chinese in traditional script/simplified script/pinyin	Taxonomy	Listed in 2020 TCM pharmacopeia	IUCN Red List assessment
Animals					
Bear bile	*Fel Selenarcti et Ursi*	熊膽/熊胆/*xióng dǎn*	Asiatic black bear *Ursus thibetanus*	No (but farmed bile included as a patent medicine ingredient)	Vulnerable
Chinese moccasin	*Agkistrodon*	蕲蛇/蕲蛇/*qí shé*	Chinese moccasin *Deinagkistrodon acutus*	Yes	Not evaluated, but listed as a Class II protected species in China
Hawksbill carapace	*Carapax Eretmochelydis*	玳瑁/玳瑁/*dài mào*	Hawksbill turtle *Eretmochelys imbricate*	No	Critically endangered
Musk	*Moschus*	麝香/麝香/*shè xiāng*	Musk deer *Moschus* spp.	Yes	Siberian musk deer *Moschus moschiferus*: Vulnerable; forest/dwarf musk deer *Moschus berezovskii*: Endangered
Pangolin scales	*Squama Manitis*	穿山甲/穿山甲/*chuān shān jiǎ*	Pangolin *Manis*, *Smutsia* & *Phataginus* spp.	No (but *M. pentadactyla* scales included as a patent medicine ingredient)	Critically endangered
Reeve's turtle shell	*Plastrum Testudinis*	龜板/龟板/*guī bǎn*	Reeve's turtle *Mauremys reevesii*	Yes	Endangered
Rhino horn	*Cornu Rhinoceri*	犀牛角/犀牛角/*xī niú jiǎo*	Rhinoceroces Rhinocerotidae spp.	No	White rhino *Ceratotherium simum*: Near Threatened; greater one-horned rhino *Rhinoceros unicornis*: Vulnerable; black rhino *Diceros bicornis*, Javan rhino *Rhinoceros sondaicus* and Sumatran rhino *Dicerorhinus sumatrensis*: Critically Endangered
Saiga antelope horn	*Cornu Saigae Tataricae*	羚羊角/羚羊角/*líng yang jiǎo*	Saiga antelope *Saiga tatarica*	Yes	Critically endangered
Seahorse	*Hippocampus*	海馬/海马/*hǎi mǎ*	Seahorse *Hippocampus* spp.	Yes (four species)	Great seahorse *Hippocampus kelloggi*, thorny seahorse *Hippocampus histrix*, spotted seahorse *Hippocampus kuda*, three-spot seahorse *Hippocampus trimaculatus* and Japanese seahorse *Hippocampus mohnikei*: Vulnerable
Tiger bone	*Os Tigris*	虎骨/虎骨/*hǔ gǔ*	Tiger *Panthera tigris*	No	Endangered
Plants					
Borneol	*Borneolum*	梅花冰片/梅花冰片/*méi huā bīng piàn*	Borneo camphorwood *Dryobalanops aromatica*	No	Vulnerable

(Continues)

TABLE 1 (Continued)

Ingredient name					
English	Pharmaceutical	Chinese in traditional script/simplified script/pinyin	Taxonomy	Listed in 2020 TCM pharmacopeia	IUCN Red List assessment
Eucommia bark	*Cortex Eucommiae*	杜仲/杜仲/*dù zhòng*	Eucommia *Eucommia ulmoides*	Yes	Vulnerable
Ginkgo seed & Ginkgo leaf	*Semen Ginkgo*	白果/白果/*bái guǒ* & 銀杏葉片/银杏叶片/*yín xìng yè piàn*	Ginkgo *Ginkgo biloba*	Yes	Endangered (although widely cultivated for more than 1,000 years and used globally as an ornamental)
Golden larch bark	*Cortex Pseudolaricis*	土荊皮/土荆皮/*tǔ jīng pí*	Golden larch *Pseudolarix amabilis*	Yes	Vulnerable
Golden thread	*Rhizoma Coptidis*	黃連/黄连/*huáng lián*	Goldthread *Coptis* spp.	Yes	Chinese goldthread *Coptis chinensis*: Not evaluated; Yunnan goldthread *Coptis teeta*: Endangered
Officinal Dendrobium stem	*Herba Dendrobii Officinalis*	鐵皮石斛/铁皮石斛/*tiě pí shí hú*	*Dendrobium officinale*	Yes	Critically endangered
Officinal magnolia bark & Officinal magnolia flower	*Cortex Magnoliae Officinalis* & *Flos Magnoliae Officinalis*	厚朴/厚朴/*hòu pǔ* & 厚朴花/厚朴花/*hòu pǔ huā*	Houpo *Magnolia officinalis*	Yes	Endangered
Storax	*Styrax*	蘇合香/苏合香/*sū hé xiāng*	Oriental sweetgum *Liquidambar orientalis*	Yes	Endangered
Tall Gastrodia tuber	*Rhizoma Gastrodiae*	天麻/天麻/*tiān má*	Tall Gastrodia *Gastrodia elata*	Yes	Vulnerable
Fungi					
Caterpillar fungus	*Cordyceps*	冬蟲夏草/冬虫夏草/*dōng chóng xià cǎo*	Caterpillar fungus *Ophiocordyceps sinensis*	Yes	Vulnerable
Matsutake mushroom	*Tricholoma Matsutake*	松蕈/松蕈/*sōng xùn*	Matsutake mushroom *Tricholoma matsutake*	No	Vulnerable

[a]n.b. some ingredients are derived from multiple species without product differentiation, and not all species utilized for these ingredients may be listed here; some ingredients which have been removed from the official TCM pharmacopoeia can still be found in patent medicines, and not all may have been identified here.

personal and collective identity (Jovchelovitch & Gervais, 1999; Smith, 2018a). Some researchers argue that changing values and culture—not just the behaviour of individuals—is necessary to reduce threats to species (Dickman et al., 2015; Ives & Fischer, 2017; Kendal & Raymond, 2018). However, achieving major changes in culture and behaviour can be challenging, especially in the short term (Manfredo, Bruskotter, et al., 2017). Traditional Chinese Medicine evolves continuously, and efforts to cultivate a culture of sustainability in TCM will be most likely to find success if they are endogenous and practicable (Kendal & Raymond, 2018; Manfredo, Bruskotter, et al., 2017; Schumacher, 2015). In recent years, sustainability has been highlighted as a central component of the Chinese government's development strategy (Wu et al., 2019), and the TCM sector has also seen increasing emphasis on the need for resources to be utilized sustainably (Chen et al., 2016; Li et al., 2015).

Understanding cultural values can help conservationists develop more effective solutions to conservation issues; overlooking sociocultural complexities can undermine conservation (Bennett et al., 2017; Manfredo, Teel, et al., 2017; Margulies et al., 2019). It is critically important for policies to be appropriate for the characteristics and circumstances of the societies that they affect. Top-down, enforcement-led approaches to wildlife management, like international trade restrictions, are most effective when they are built on values that are

consistent with those that are held by the communities that are most impacted (Challender et al., 2015; Cooney et al., 2017; Hirata, 2005). Trade and consumption restrictions are commonly justified with the insistence that products like rhino horn have 'no medicinal value' (UNEP, 2018). Even where such rhetoric is fully supported with biomedical evidence, TCM stakeholders are likely to insist on their evidence, as it is grounded in TCM theory. As a matter of colliding worldviews, the literature on cultural cognition and motivated reasoning shows that people tend to seek out and credit information that supports their worldview and have difficulty trusting information that challenges it (Kahan, 2013; Kahan et al., 2012; Kraft et al., 2015; Nisbet et al., 2015). Furthermore, behaviour change interventions that misrepresent or are dismissive of traditional practices risk sowing distrust, damaging credibility and alienating critical stakeholders (Margulies et al., 2019; Smith, 2018b). For instance, demand reduction campaigns framed around the message that consuming rhino horn for medicinal purposes is analogous to biting your fingernails have attracted such criticism (Smith, 2018b).

Ecologically destructive behaviours are not justified by cultural significance (Dickman et al., 2015), and well-designed conservation efforts can potentially change behaviours if executed carefully (Olmedo et al., 2018). However, socially incompatible conservation policies are challenging to implement, and can provoke backlash (Challender et al., 2015; Manfredo, Teel, et al., 2017; St. John et al., 2018). Attitudes toward the consumptive use of wildlife in Chinese and Chinese-influenced cultures across Asia tend to be relatively permissive (Swan & Conrad, 2014). Where communities see the consumptive use of natural resources as a legitimate part of their lives and livelihoods, regulatory compliance can be found wanting if restrictions conflict with traditional practices, values and livelihoods (Conrad, 2012; Holt, 2005; Swan & Conrad, 2014). Conservation efforts can be rendered ineffective if solutions are not contextually appropriate for key stakeholders (Biggs et al., 2019). As argued here, a stronger understanding of TCM theory and practice can facilitate the work of conservationists in pursuit of more sustainable solutions and more constructive engagement.

3.3 | Incorporating TCM into conservation discourse and decision-making

The nuances of TCM often get lost in translation when discussed in conservation. For example, rhino horn is sometimes characterized as a treatment for high fever (Graham-Rowe, 2011; Kennaugh, 2016), but likening it to aspirin or paracetamol reflects a fundamental misunderstanding of TCM: rhino horn's cold properties are appropriate for disharmonies characterized by severe heat, whether or not the patient is feverish (rhino horn is also not a commonly used material, as are the aforementioned over-the-counter painkillers; Bensky et al., 2004). If a cold pattern of disharmony presents as fever, rhino horn is unsuitable. As a potent cold-type CMM, it would only be suitable for addressing a severe heat-based disharmony (Hanson, 2011; Koh, 2010). One such severe heat-based disharmony is severe acute respiratory syndrome, the outbreak of which was considered an infectious warm-disease epidemic or *wenyi* (温疫/温疫/*wēn yì*; epidemic of *wenbing*, 温病/温病/*wēn bìng*). In order to treat such a severe heat-based disharmony, TCM experts have noted that decoctions containing rhino horn may have been applicable as a cold-type CMM (Hanson, 2011; Koh, 2010). In such instances, rhino horn is seen as a powerful medicine of last resort in an evolving and potentially lethal *wenyi*, though it should be emphasized that food remedies may avert such conditions if taken at an early stage according to TCM rationale (Hsu et al., 2020). Getting the details of TCM rationale right (alongside an analysis of the social situation overall) is crucial for understanding the role of wildlife products in TCM, as a first step towards developing effective solutions to unsustainable use of species threatened by trade for TCM.

Recognizing cultural differences in concepts of health and illness can help conservationists intervene appropriately for species that are consumed medicinally at unsustainable rates. Despite the use of TCM alongside biomedicine being commonly practiced, it is not prudent to assume that biomedical alternatives will be accepted as wholesale substitutes for TCM treatments (von Hippel et al., 2006). It is critical to understand what influences an individual's choice to use a given TCM product, including how they perceive the product and how their trust in the product was formed. Such sociocultural insight can be used to develop interventions more strategically, which are better targeted at particular demographic groups, specific product choices and contexts (Doughty et al., 2019; Heberlein, 2012).

Conservation approaches increasingly emphasize inter-agency cooperation and local community engagement, particularly in source countries of illegally traded wildlife goods (Cooney et al., 2017). Opportunities to engage with demand-side stakeholders like the TCM community should also be explored, beginning with building trust and partnerships with regulatory agencies, practitioners, professional bodies and pharmaceutical manufacturers (St. John et al., 2018; Young et al., 2016). Traditional Chinese Medicine experts can provide nuanced insight to deepen conservationists' understanding of consumption patterns and demand for wildlife products. Engagement with TCM stakeholders can be useful in pursuing more sustainable solutions. For instance, identifying substitutes for products derived from threatened or protected species invariably requires conservationists to meaningfully engage and collaborate with TCM stakeholders. The insight that TCM stakeholders can provide could help conservationists assess the viability of conservation solutions both medically and ecologically before they are implemented, thus ensuring that conservation problems are not compounded (da Nóbrega Alves et al., 2008). In this sense, the knowledge and insight of TCM experts can be incorporated into decision-making in a cross-cultural, collaborative manner akin to how conservationists have engaged with traditional ecological knowledge-holders (Berkes, 2008; Whyte, 2013). Input from TCM community members can strengthen demand reduction interventions, ensuring that their objectives and communications are socially appropriate and resonate with target groups.

While the priorities of TCM stakeholders and conservationists may not be perfectly aligned, we stress that TCM is not fundamentally at odds with conservation. Indeed, the founding principle of TCM is that humans are one with nature—good health hinges on finding balance with our environment (Kaptchuk, 2000; Stevenson et al., 2009). Furthermore, it is not in the interests of TCM to severely deplete or drive to extinction any of the medicinal species that it values and utilizes, and the TCM community recognizes the importance of sustainability in ensuring the long-term future of their medical system and industry (Booker et al., 2015; Chen et al., 2015; Cunningham, Brinckmann, Pei, et al., 2018; Cunningham et al., 2020; Li et al., 2015). Illegal and unsustainable wildlife use is not officially sanctioned by the TCM authorities, and so there should be common ground between TCM stakeholders and conservationists in finding ways forward. Engaging and collaborating with TCM stakeholders in developing conservation policies can help both sides reach compromises, such that the implementation of these policies can be accepted, adhered to or even embraced.

We acknowledge that the challenge of the illegal and unsustainable use of wildlife for TCM cannot be solved by better engagement with TCM stakeholders alone. Wildlife products, traders and consumers are highly varied, and wildlife trade is dynamic and influenced by wider societal problems like corruption and poverty (Phelps et al., 2016; 't Sas-Rolfes et al., 2019). This requires understanding and empathy as a first step on the pathway to finding sustainable conservation solutions.

4 | CONCLUSION

Traditional practices can contribute to conservation problems, but efforts to shift entrenched values and beliefs are unlikely to achieve practical conservation gains, especially in the short term (Manfredo, Bruskotter, et al., 2017). TCM use is not necessarily tied to a lack of information, and providing scientific evidence or promoting biomedical alternatives may not influence decisions and behaviours (Verhoef et al., 2007). The active promotion of TCM by the Chinese government both domestically and in its foreign policy makes it clear that TCM is here to stay. The challenge for conservationists, therefore, is to work together proactively with TCM stakeholders to find sustainable solutions (Hinsley et al., 2020).

The deep cultural roots of TCM that are woven into people's daily lives can make inducing change exceedingly difficult, and conservation efforts that are perceived as disparaging of TCM can alienate critical stakeholders. Joint forums to facilitate respectful and informed dialogue between TCM stakeholders and conservationists, along with detailed behavioural research with consumers, can help in balancing TCM needs with conservation objectives. Interventions and policies that consider the perspectives of affected stakeholders can succeed in producing a desired change (Heberlein, 2012). The success of the initiative to sustainably harvest southern *Schisandra* fruit in panda habitat (Brinckmann et al., 2018) demonstrates that cooperation between conservationists and TCM stakeholders can indeed produce positive conservation outcomes while facilitating sustainable TCM development. Recognizing the cultural significance of TCM and gaining a working knowledge of this medical system can empower conservationists to find solutions that work for both TCM stakeholders and the biodiversity that we all wish to safeguard.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

H.C. developed the central idea, did the literature review and led the writing of the manuscript with guidance from D.B. and H.P.P.; H.D., A.H., E.H., T.M.L. and E.J.M.-G. contributed critically to the writing of the manuscript, and had major input in shaping its direction and arguments. All authors gave final approval for publication.

DATA AVAILABILITY STATEMENT

No data were used in this work.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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