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## Is China's unparalleled and understudied bee diversity at risk?

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### ABSTRACT

China is one of the most significant providers of pollination ecosystem services globally. In addition to having unparalleled bee diversity, China has more than eight million managed bee colonies, and it is the world's major honey producer. Yet, pollinators in China, especially bumble bees (*Bombus* spp.) and honey bees (*Apis* spp.), are likely at risk. Massive pollinator declines in various countries have rightly grabbed the attention of beekeepers, scientists, policymakers, and the general public, but research has almost exclusively focused on the U.S. and Europe, while countries with significantly higher pollination resources (such as China) have received far less attention. This perspective piece questions and highlights the risks to wild and managed pollinators in China and critical research gaps. We show that there may be a “pollination gap” in China for crops dependent on insect pollination and we examine the potential causes. Specifically, we assess the risks associated with land-use intensification, pesticide poisoning, climate change, invasive species, and other factors affecting the survival of bee pollinators in Asia. If true, the effects of declining pollinator populations in China would be felt globally, and with so much at stake, this problem merits careful consideration in the development of agriculture, economic, and conservation policies.

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### 1. Introduction

Honey bees (*Apis* spp.), bumble bees (*Bombus* spp.), and other bee pollinators are key to maintaining a healthy ecosystem, and they deliver irreplaceable benefits to humans (Daily et al., 1997; Millennium Ecosystem Assessment, 2005). The most commonly-known services that bees provide are honey production and essential crop pollination. Yet, many lesser-known values offered by bee pollinators have now been defined, and in some cases, quantified. These services include enhanced landscapes (from pollen dispersal), crop quality, medicinal remedies, and overall ecosystem vigor (Buchmann and Nabhan, 1997; Fiedler et al., 2008; Garratt et al., 2014; Losey and Vaughan, 2006).

China is the largest honey producer in the world. With an annual harvest of over 400,000 metric tons (FAOSTAT, 2012), it produces over four times more honey than Turkey, its closest rival. China is perhaps also the largest provider of pollination ecosystem services globally. Home to several relatively-rare honey bee species, China boasts a nearly unparalleled diversity of both managed and wild *Apis* species (Hepburn and Radloff, 2011).

Moreover, China is also home to incredible diversity of non-*Apis* bees. For instance, the region of eastern Qinghai-Tibetan Plateau is the richest in global bumblebee species, especially in Gansu and Sichuan, where each province contains more than 20% of global species' records (An et al., 2014; Williams et al., 2015; Williams et al., 2009).

There has been a lot of research on the importance of, and risks to, bee pollinators in many regions around the world; however, few studies have analyzed the situation in China. In this paper, we highlight critical gaps in the knowledge necessary for understanding threats to bee pollinators and informing conservation efforts in China. Specifically, we (1) review the global risks to pollinators and lack of research on this topic in China, (2) compare and contrast the globally significant role of China for providing pollination services, (3) assess threats to China's bee pollinators and lack of research on this topic, (4) examine the possible economic, environmental, and social consequences of bee diversity declines within China, and (5) propose a framework for conservation actions.

### 2. Global risks to pollinators and the state of research in China

#### 2.1. Global pollinator concern

There is growing and worldwide concern over declines in pollinators and pollination services they provide (Potts et al., 2010; Vanbergen et

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al., 2013). News headlines of massive honey bee colony losses in many regions of the globe have grabbed the attention of beekeepers, ecologists, economists, and many other stakeholders (Neumann and Carreck, 2010).

Wild bee pollinators are likely to be at greatest risk from environmental factors (Goulson et al., 2008; Williams and Osborne, 2009), whereas managed honey bee populations are declining in many agrarian areas due to diseases, pests, and poor agricultural management practices (Potts et al., 2010).

Many countries experiencing wild pollinator shortages, like the U.S., now largely rely on a single managed species (e.g. the Western honey bee *Apis mellifera*) (Cobey et al., 2011). The Western honey bee has several unmatched qualities such as multi-crop compatibility, year-round pollination ability, capability to forage relatively-long distances, and large populations per colony (Bauer and Wing, 2010). However, the dependence on a sole pollinator species and a narrow genetic stock also presents considerable risks to national economies, agriculture, and food security.

Recent national and regional research has suggested that there may be a global gap between pollinator availability and pollination demand (Aizen and Harder, 2009; Thomann et al., 2013). Since 1961, the global number of managed honey bee hives has increased by about 45%, while, at the same time, the demand for pollination of specialty pollinator-dependent crops increased by more than 300%—significantly outstripping the growth of managed pollinators (Aizen and Harder, 2009).

In China, managed pollinators have increased more than in other regions (>160% since 1961) (NBS, 2014; FAOSTAT, 2013). However, managed honey bee colonies density per area of pollinator-dependent crops has remained mostly constant (Fig. 1), and China appears to have a lower-than-average managed colony density compared to other countries (Hou and Zhang, 2011). To make matters worse, there are numerous regional reports of declines of some economically-important pollinators, such as honey bees (He and Liu, 2011; Hou and Zhang, 2011; Liu and Tan, 2012; Partap and Ya, 2012; Z.Z Ren et al., 2014, Z.X Ren et al., 2014), bumble bees (Xie and An, 2014; Xie et al., 2008; Williams and Osborne, 2009), and solitary bees (Xie et al., 2013). Furthermore, China features four of the 25 already-threatened global biodiversity hotspots, and we've identified a new "Priority Region for Pollinator Conservation" where three hotspots overlap with unparalleled endemic bee species diversity (Fig. 2). Consequently, pollinator conservation can hardly be overstated in its importance in Asia and beyond.

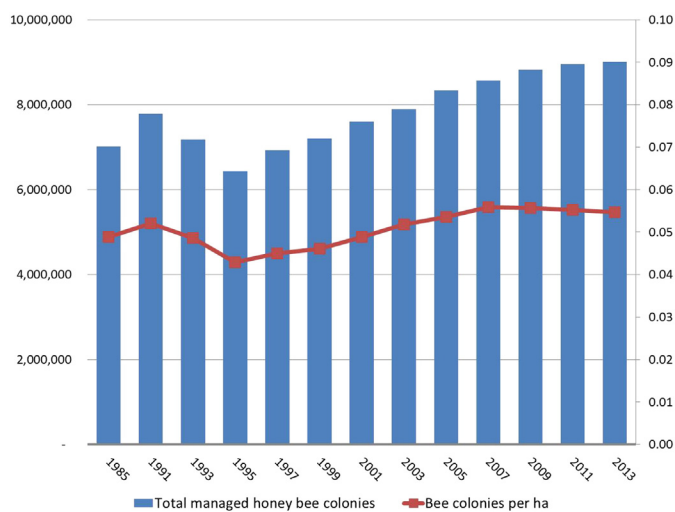


Fig. 1. Managed honey bee colonies and density in China from 1985 until 2013. Sources: NBS (2014) and FAOSTAT (2013). Managed honey bee colonies density per area of pollinator-dependent crops has remained mostly constant over the years.

## 2.2. Literature gaps in China

In reviewing literature on the topic of pollinator ecology in China, we found a rather striking lack of scientific research on this topic. Using Web of Science™ with the search terms “pollinator ecology”, out of 1546 English publications, we found only 62 (4.01%) that mentioned China. Focusing on risks to pollinators, using the search terms “pollinator decline” or “Colony Collapse Disorder” and similar search terms returned a total 529 publications, of which a mere seven (1.32%) mentioned China. A search of the China National Knowledge Infrastructure (CNKI) using similar Chinese search terms yielded even fewer publications (see Supplementary support materials), and only a couple of them were primary research in China.

There is thus a striking mismatch between China's vast and unparalleled pollinator diversity and the body of available research, and we believe that there is an urgent need to increase understanding of this overlooked field.

## 3. China's globally-significant role in pollinator diversity

China's managed apiaries number at least three or four times more than that of the U.S., and account for almost 10% of the global supply (Chen and Wang, 2012). Moreover, the managed Western honey bee (*A. mellifera*) appears to be increasing their hive numbers in China in recent decades (An and Chen, 2011; Cvitković et al., 2009; Kluser et al., 2010; Kuang and Kuang, 2003).

Unlike in Europe and North America, beekeepers in China widely use two distinct species of managed pollinators: the indigenous, semi-domesticated Asian honey bee (*Apis cerana*—currently estimated at a little less than three million hives nationally) (Jiang, 2013) and the non-native Western honey bee (*A. mellifera*—projected at more than five million hives) (FAOSTAT, 2013; Jiang, 2013). The Western honey bee was first introduced to China as early as 1896 (Yang, 2005). Even within the native species of *A. cerana*, there are numerous sub-species, some wild, which are present in areas of China (He et al., 1999; Zhao et al., 2014), which underscores China's global importance as a resource of genetic variation in bee pollinators.

China harbors a very high diversity of wild honey bee (*Apis*) species—both at the species, and at the genetic/colony level. The so-called wild black bees, *A. mellifera* ssp., are protected in northeastern China. Since 1999, a nature reserve has been established in Helongjiang, China that promotes restoration of native plants and restricts movement of non-native bees in the area (Z.Z Ren et al., 2014, Z.X Ren et al., 2014; Wang et al., 2003). Nowadays, it is estimated that there are more than 40,000 colonies within the nature reserve, increasing from 8000 colonies in 1999.

Furthermore, China supports at least six of the nine currently-recognized honey bee species in the world (Fig. 3), with at least two additional *Apis* species proposed recently. Many of China's wild *Apis* species provide important pollination services, including *Apis florea*, *Apis andreniformis*, *Apis dorsata*, and *Apis laboriosa* in southern and western China (Liu and Tan, 2012; Oldroyd and Wongsiri, 2006). In addition, China supports multiple important other bee pollinators, such as bumble bees, and various species of stingless bees and solitary bees which are also uniquely diverse in China.

Interestingly, Chinese farmers do not leverage managed pollinators for optimizing crop yields across the country, accounting for less than 5% of hives being leased (An and Chen, 2011). From our own observations, this is likely because of a lack of understanding of the pollination benefits provided by bees, as well as a traditional dependence on wild bees to (knowingly or not) pollinate crops. This is in contrast to more than 50% of managed bees in the U.S. and Europe being leased by farms or agricultural companies, which is leading to the mass spread of bee diseases that affects both managed and wild species (Wilfert et al., 2016). While there remain many beekeepers in China who move from place to place with their bees, they do not appear to be nearly as

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