Local Food and Transnational Science:
New Boundary Issues of the Caterpillar Fungus in Republican China

*by Di Lu**

ABSTRACT

This article focuses on new boundary issues that have emerged from the encounter of modern science from abroad and local foodstuffs exemplified by the caterpillar fungus in Republican China (1912–49). The caterpillar fungus was believed in premodern Chinese society to be able to reversibly transform from a blade of grass to a worm, thereby crossing boundaries between two species. It had different uses, ranging from a culinary ingredient to a medicinal substance, and in this way also crossed boundaries of identity. At the beginning of the twentieth century, scientific scholarship from Japan began to bring new perceptions of the fungus to Chinese society through translation. Modern science expanded human vision into the microscopic structure of the caterpillar fungus, and deconstructed it into two nontransformable species grouped with other similar species. The Chinese term for it also entered the Japanese language. However, the category of the term was broadened, crossing the boundary between the caterpillar fungus and other similar species, thereby indicating semantic boundaries of shared vocabulary. As local food or material culture in Republican China engaged scientific attention, the caterpillar fungus as a disenchanted wonder of nature sometimes transformed into a scientific wonder, eliciting new explorations within different scientific boundaries. The new scholarship led to tensions and negotiations between domains of knowledge about this organism but would not necessarily drive out the vernacular culinary or medical expertise. The emergent boundary issues overall depict both rupture and continuity in modern Chinese food knowledge.

What is the caterpillar fungus? The Englishman James Everard Home (1798–1853) collected specimens during the period 1841–46 when he was captain of the *North Star*; at the beginning of that time, he was also engaged in the Sino-British Opium War (1839–42).[1] He once presented the museum of the Royal College of Surgeons of England with a "series of specimens of *Sphaeria Sinensis*, Berk., tied up in a bundle

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[1] "Obituary: Capt. Sir Jas. Everard Home, Bart.," *The Gentleman's Magazine and Historical Review* 41 (1854): 423; Emil Bretschneider, *History of European Botanical Discoveries in China*, vol. 1

with silk, as sold in the market of Canton." Probably based on Home's information, the museum remarked that these "are used medicinally in cases where the powers of the system have been reduced by over-exertion or sickness."[2] The species "*Sphaeria Sinensis*," now commonly known as *Cordyceps sinensis* (or *Ophiocordyceps sinensis*) or the caterpillar fungus, initially appeared as an aphrodisiac in a fifteenth-century Tibetan medical text, and then started attracting the attention of Chinese authors from the early eighteenth century.[3] A 1757 Chinese text explains that in winter the caterpillar fungus stays in the ground, is able to move, and resembles a piliferous old silkworm; while in summer, its hair grows out of the ground and turns into a blade of grass together with the body. If not gathered in summer, it would turn into a worm again in the coming winter. This little organism, sweet and balanced, can protect the lung, benefit the kidney, stop bleeding, disperse phlegm, and eliminate coughing due to exhaustion.[4] However, contemporary biology explains its formation as the fungus's infection of the larvae of some moth species belonging to the family Hepialidae, with the consequent outgrowth in the form of fruiting bodies that emerge from the heads of the larvae.[5]

Although the focus of the museum's 1860 explanation is squarely on medicine, the caterpillar fungus was actually also an esteemed foodstuff, aphrodisiac, tonic, transformable natural curiosity, profitable product, and so forth. The French Jesuit missionary Dominicus Parennin had eaten duck simmered with this substance in Beijing in 1720, which thereby restored his extremely feeble body.[6] Frederick J. Simoons's 1991 monograph on Chinese food culture discloses that "recently in a Friendship Store in Canton frequented by foreigners, we found cans (380 gm.) of 'Stewed Cordyceps Sinensis with Chicken in Soup,' a product manufactured by the China National Medicines and Health Products Import and Export Corporation, Chungking Branch (Szechwan)."[7] The caterpillar fungus in these two cases can hardly be simply treated as a dietary ingredient or medicinal substance.[8] To date, historical scholarship on Chinese food has seldom given attention to changing natural knowledge about food in connection with the globalization of modern science.[9] The multiple roles of the caterpillar fungus nevertheless enable historians to examine Chinese food across

(London: Sampson Low, Marston, 1898), 362; compare these to William H. Flower, *Catalogue of the Specimens Illustrating the Osteology and Dentition of Vertebrated Animals, Recent and Extinct, Contained in the Museum of the Royal College of Surgeons of England, Part I* (London: Printed for the College, 1879), 205.

[2] *Catalogue of the Contents of the Museum of the Royal College of Surgeons of England, Part 1, Plants and Invertebrate Animals in the Dried State* (London: Taylor and Francis, 1860), 23.

[3] Daniel Winkler, "Caterpillar Fungus (*Ophiocordyceps sinensis*) Production and Sustainability on the Tibetan Plateau and in the Himalayas," *Asian Medicine* 5 (2009): 291–316.

[4] Wu Yiluo, *Bencao Congxin* (1757; repr., Shanghai: Shanghai Kexue Jishu Chubanshe, 1982), 36.

[5] Yongjie Zhang, Erwei Li, Chengshu Wang, Yuling Li, and Xingzhong Liu, "*Ophiocordyceps sinensis*, the Flagship Fungus of China: Terminology, Life Strategy and Ecology," *Mycology* 3 (2012): 2–10.

[6] Jean-Baptiste Du Halde, ed., *Lettres édifiantes et curieuses, écrites des missions étrangères*, vol. 10 (Lyon: J. Vernarel, 1819), 470–85.

[7] Frederick J. Simoons, *Food in China: A Cultural and Historical Inquiry* (Boca Raton, Fl.: CRC, 1991), 323–4.

[8] Eugene N. Anderson devotes a whole chapter to "traditional medical values of food"; see Anderson, *The Food of China* (New Haven, Conn.: Yale Univ. Press, 1988), 229–43.

[9] For examples, see Kwang-Chih Chang, ed., *Food in Chinese Culture: Anthropological and Historical Perspectives* (New Haven, Conn.: Yale Univ. Press, 1977); Hsing-Tsung Huang, *Science and Civilisation in China: Fermentations and Food Science* (Cambridge: Cambridge Univ. Press, 2000);

categories of knowledge. Though some have outlined the history of this organism in Eurasia by around the end of the nineteenth century, the involvement of modern science in tensions and negotiations among boundaries of natural knowledge about the organism in modern Chinese society remains little explored.[10] And it is already known that the Chinese state's pursuit of science as modernity upheld the discursive power of science in the first half of the twentieth century, which promoted the deconstruction of local natural knowledge.[11] Through a case study of the caterpillar fungus, this article probes new boundary issues that emerged from the encounter of local food with modern science in Republican China, and traces them to changing scholarship in nineteenth-century Japan and its influence on the Chinese people within transnational networks of knowledge.

PRODUCTION AND CONSUMPTION OF THE CATERPILLAR FUNGUS IN REPUBLICAN CHINA

According to Sherman Cochran, science played a strategic role in modern Chinese consumer culture.[12] However, the promotion of native edible substances or tonics in modern Chinese food culture would not necessarily invoke the power of science. Traditional accounts of the potency and transformative ability of the caterpillar fungus, for example, were able to provide impetus for the consumption of this product. However, deconstruction of its transformation in a scientific context, which has not yet been found in modern Chinese commercial advertisements, would perhaps undermine its sales. Nevertheless, the scientific enterprise in modern Chinese society wielded a growing influence on the public understanding of natural objects. The noted scholar Hu Shi, who had studied at Cornell University and Columbia University from 1910 to 1917, wrote in 1923: "In the recent three decades, a term has obtained a supreme position in China; one dares not look down upon or sneer at it whether he/she understands it or not, and whether he/she is fogyish or revolutionary. That term is 'science.'" Further, he pointed out that this "science" enjoyed nearly unanimous admiration throughout the country.[13] Under the influence of the style of this "science," as stressed by Hu Shi, the knowledge surrounding the caterpillar fungus was undergoing reconstruction.

New perceptions of the caterpillar fungus emerging in Chinese society in the first half of the twentieth century were initially elicited by Japanese scholarship. And

John A. G. Roberts, *China to Chinatown: Chinese Food in the West* (London: Reaktion, 2002); and Seung-Joon Lee, *Gourmets in the Land of Famine: The Culture and Politics of Rice in Modern Canton* (Stanford, Calif.: Stanford Univ. Press, 2011).

[10] Carla Nappi, *The Monkey and the Inkpot: Natural History and Its Transformations in Early Modern China* (Cambridge, Mass.: Harvard Univ. Press, 2009), 141–6; Bhushan Shrestha, Weimin Zhang, Yongjie Zhang, and Xingzhong Liu, "What is the Chinese Caterpillar Fungus *Ophiocordyceps sinensis* (Ophiocordycipitaceae)?" *Mycology* 1 (2010): 228–36; Di Lu, "Transnational Travels of the Caterpillar Fungus in the Fifteenth through Nineteenth Centuries: The Transformation of Natural Knowledge in a Global Context," *Asian Medicine* 12 (2017): 7–55.

[11] Sean Hsiang-Lin Lei, *Neither Donkey nor Horse: Medicine in the Struggle over China's Modernity* (Chicago: Univ. of Chicago Press, 2014), 91–6, 141–66. See also Ding Fubao, *Huaxue Shiyan Xinbencao (Xu)* (Shanghai: Wenming Shuju, 1909), 1–2; Chen Cunren, ed., *Zhongguo Yaoxue Dacidian* (Shanghai: Shijie Shuju, 1935), 1, 7–8; and Ding, *Chouyin Jushi Zizhuan* (Shanghai: Gulin Jingshe Chubanbu, 1948), 18–19.

[12] Sherman Cochran, *Chinese Medicine Men: Consumer Culture in China and Southeast Asia* (Cambridge, Mass.: Harvard Univ. Press, 2006), 109–15.

[13] Hu Shi, "Kexue Yu Renshengguan Xu," in *Hushi Wenji*, book 3, ed. Ouyang Zhesheng (Beijing: Beijing Daxue Chubanshe, 1998), 151–65.

Japan's acquisition of the scientific norms of European civilization benefited much from *rangaku* (Dutch learning), which spread among Japanese intellectuals in the context of the country's commercial exchange with the Netherlands, the only European country allowed to trade with Japan from the 1640s to 1854.[14] Though Dutch learning did not proceed smoothly due to ideological and political issues, European biological and medical knowledge was still periodically translated into Japanese.[15] A series of international and domestic incidents, including China's defeat in its two opium wars with European powers, and the conclusion of the Treaty of Kanagawa between the United States and Japan in 1854, provoked Japanese reflections on national destiny and modernization, and prompted the expansion of Japan's openness to the world as well as to Western science and technology.[16] In 1869, the newly established Meiji government set out to promote the German medicine it officially recognized.[17] Scientific communities and institutionalized scientific research arose in Meiji Japan.[18] And, as Morris Low indicates, Meiji science was tied to the "pursuit of national interests and profit," and "mobilized under an ideology aimed at building a nation-state."[19] Contrary to the booming of German medicine or modern science, native Kampo medicine suffered official oppression and fell into a dilemma of legitimacy several years after the Meiji restoration.[20] Meanwhile, the natural substances used in both Chinese and Kampo medicine became objects of chemical, biological, and pharmacological research supported by, for example, the Pharmaceutical Society of Japan.[21] Such new scholarship

[14] For the history of Dutch learning in Japan and its influence on Japanese scholarship, see Sugita Genpaku, *Rangaku Kotohajime* (1815; repr., Tokyo: Tenshinrō, 1869); Grant R. Goodman, *Japan: The Dutch Experience* (London: Athlone, 1986); and Federico Marcon, *The Knowledge of Nature and the Nature of Knowledge in Early Modern Japan* (Chicago: Univ. of Chicago Press, 2015), 127–39.

[15] Goodman, *Japan: The Dutch Experience* (cit. n. 14), 190–222. For examples, see Noro Genjō, *Oranda Honzō Wage* (Tokyo: National Diet Library, 1742–50); Hirokawa Kai, *Ranryō Yakukai* (Heian: Hayashi Gonbee, 1806); Kō Ryōsai, *Ranhō Naiyō Yakunōshiki* (Osaka: Shōendō, 1836); and Tsuboi Shinryō, *Shinyaku Hyakuhinkō* (Tokyo: Shimamura Risuke, 1866).

[16] Robert Hans van Gulik, "Kakkaron: A Japanese Echo of the Opium War," *Monumenta Serica* 4 (1940): 478–545; John K. Fairbank and Kwang-Ching Liu, eds., *The Cambridge History of China*, vol. 11, *Late Ch'ing, 1800–1911*, pt. 2 (Cambridge: Cambridge Univ. Press, 1980), 340–3; Masayoshi Sugimoto and David L. Swain, *Science and Culture in Traditional Japan* (Tokyo: Charles E. Tuttle, 1989), 291–346; Bob Tadashi Wakabayashi, "Opium, Expulsion, Sovereignty: China's Lessons for Bakumatsu Japan," *Monumenta Nipponica* 47 (1992): 1–25; Marius B. Jansen, *The Making of Modern Japan* (Cambridge, Mass.: Harvard Univ. Press, 2002), 257–93.

[17] John Z. Bowers, *When the Twain Meet: The Rise of Western Medicine in Japan* (Baltimore: Johns Hopkins Univ. Press, 1980), 105–7; Yoshio Izumi and Kazuo Isozumi, "Modern Japanese Medical History and the European Influence," *The Keio Journal of Medicine* 50 (2001): 91–9. For the German influence in the making of Meiji Japan, see Hoi-eun Kim, "Made in Meiji Japan: German Expatriates, German-Educated Japanese Elites and the Construction of Germanness," *Geschichte und Gesellschaft* 41 (2015): 288–320.

[18] Yuasa Mitsutomo, "The Growth of Scientific Communities in Japan," *Japanese Studies in the History of Science* 9 (1970): 137–58; James R. Bartholomew, *The Formation of Science in Japan: Building a Research Tradition* (New Haven, Conn.: Yale Univ. Press, 1989), 49–67.

[19] Morris Low, *Science and the Building of a New Japan* (New York, N.Y.: Palgrave Macmillan, 2005), 7–8.

[20] Shigeo Sugiyama, "Traditional Kampo Medicine: Unauthenticated in the Meiji Era," *Historia Scientiarum* 13 (2004): 209–23.

[21] This society launched the *Yakugaku Zasshi* (Journal of the Pharmaceutical Society of Japan) in 1881, which was devoted to modern pharmaceutical research. See also Yakazu Dōmei, "Meiji Jidai Ni Okeru Kanyaku no Yakurigakuteki Kenkyū Gyōseki To Sono Shiteki Kōsatsu: Shutoshite Inoko Yoshitoshi No Kanyaku Kenkyū O Megutte," *Nihon Tōyō Igaku Zasshi* 13 (1962): 111–19; and Yasuo Otsuka, "Chinese Traditional Medicine in Japan," in *Asian Medical Systems: A Comparative Study*, ed. Charles M. Leslie (Berkeley and Los Angeles: Univ. of California Press, 1976), 322–40.

on natural (medicinal) substances even affected some Chinese students educated in Japanese schools in the 1900s, though the caterpillar fungus and other insect-fungi had as yet received little attention from the field of pharmacology.[22]

The caterpillar fungus retained its popularity in Chinese society. As the twentieth century commenced, caterpillar fungus found growing in Tibet began to be recorded as a medicinal product in local chronicles; this suggested increasing local attention to its medicinal or commercial value.[23] Geographically considered, when this product from Tibet was transported eastward, it had to first pass through Sichuan, Yunnan, and/or Qinghai, where it also grew. According to an investigation in 1919, for example, the caterpillar fungus was then already a special export product of Yushu, Qinghai. Many people were collecting it there and trading with merchants; the collecting activities even bred discontent among local headmen, who thought that the "pulse" of the land was thus being broken by the impact of digging for this product, and many flocks and herds were dying in consequence.[24] In 1937, the caterpillar fungus was still listed among the medicinal substances that constituted a significant percentage of the special local products of Yushu.[25] Doubtless the trade in this product contributed to the local economy in Yushu, despite tensions between local headmen and merchants. Compared with Tibet and Qinghai, however, Sichuan and Yunnan were more widely known as the areas where it grew naturally.

An extensive survey of products in postal delivery areas of China, conducted by the General Post Office of the Ministry of Communications during the period from the spring of 1934 to February 1936, enables an overview of the production and nationwide dissemination of the caterpillar fungus in the mid-1930s. With this investigation came a book published in 1937, whose prefaces indicated its aim of giving a general idea of available Chinese products so as to facilitate their procurement. Underlying the investigation was the belief that the flourishing of local commodities on the national market would help rescue the war-beleaguered national economy from shortages and crises, while simultaneously improving the postal services.[26] The investigation, though excluding a few regions such as today's western Tibet, reveals the importance of the Yangtze River in transporting the caterpillar fungus from its production areas to southeastern China. The bulk of the caterpillar fungus was produced in today's Sichuan and then Yunnan provinces.[27] In particular, the caterpillar fungus from Maogong, Kangding, and Lijiang was treated as a representative product of Sichuan and Yunnan, and thus was photographed for the investigation.[28] The significance of geographical information on its areas of growth is rooted in, as Emily T.

[22] For example, see Wang Huanwen, "Bukuryō No Seibun Ni Ju Te," *Yakugaku Zasshi* 327 (1909): 461–72.

[23] For examples, see Duan Pengrui, "Yanjing Xiangtuzhi" (first published 1909); Liu Zanting, "Dingqingxian Tuzhi" (ca. 1917); and Liu Zanting, "Wucheng Xianzhi" (ca. 1921), all in *Zhongguo Difangzhi Jicheng* [Collection of local chronicles of Tibet] (repr. together, Chengdu: Bashu Shushe, 1995); 391–424, on 405; 555–578, on 573; and 129–156, on 150, respectively.

[24] Zhou Xiwu, "Yushu Diaochaji," in *Zhongguo Fangzhi Congshu* [Northwest region, book 37] (1919; repr., Taipei: Chengwen Chubanshe, 1968), 149–50, 180.

[25] Ma Hetian, *Ganqingzang Bianqu Kaochaji* (Shanghai: Shangwu Yinshuguan, 1947), 374–5, 386–8.

[26] *Zhongguo Tongyou Difang Wuchanzhi* (Shanghai: Shangwu Yinshuguan, 1937), 5–6.

[27] Ibid., 529–43, 607, 655–65, 1089.

[28] Ibid., 527, 609, 651; cf. Shina Shōbetsu Zenshi Kankōkai, *Shinshū Shina Shōbetsu Zenshi*, vol. 2 (Tokyo: Tōa Dōbunkai, 1941), 383.

Yeh and Kunga T. Lama state, "the fact that the larvae-fungus complex cannot be cultivated," which means that "nonhuman nature determines where it can and cannot be found."[29]

By the mid-1930s, price lists for medicinal products from Kangding and Lijiang demonstrate that the caterpillar fungus was significantly more expensive than most or all of the other medicinal plants and fungi, but was cheaper than medicinal animal products such as bear bile.[30] In about 1935, a drugstore of repute in Shanghai sold the caterpillar fungus for 44.24 *yuan/jin*, about 4.9–7.4 times the prices in Kangding, where it fetched 6.00–9.00 yuan/jin.[31] By comparison, common strains of rice sold in Shanghai in 1935 were a fraction of the price, around 0.067–0.080 yuan/jin.[32] A variety of other sources from the 1930s–40s both confirm the production of the caterpillar fungus in west China, and show how it sold well in Shanghai, Hong Kong, and some other cities in southeastern China.[33] In 1947, the export volume and prices of medicinal products from Chongqing (then a part of Sichuan) were reported to have recently increased significantly; some merchants trading between Guangdong and Chongqing were even willing to spend about twice as much money for the caterpillar fungus as they had before.[34] Clearly, over the decades leading up to the Communist victory, economic interests facilitated a west-east trend in the transportation of the caterpillar fungus to economically more developed areas. In November 1948, the governor of Changdu (a city in today's eastern Tibet) issued a proclamation whose first demand was the opening up of the mountains, previously forbidden by local lamaseries; this change would allow people to collect natural products (including the caterpillar fungus) there.[35] The announcement doubtless boosted collection of the caterpillar fungus and thus promoted the growth of the local economy. But today, scientists find that overexploitation and climate change are threatening the sustainability of the ecology and economy of this product.[36]

The growth and domestic circulation of products was then accompanied by lively consumer demand for them in Chinese society. In many cases, there was no distinct boundary between medicinal products and food, and tonics for improving health, rather than treating illness, were embedded throughout the region, and sold in drugstores, dispensaries, food companies, and restaurants.[37] When traditional physicians

[29] Emily T. Yeh and Kunga T. Lama, "Following the Caterpillar Fungus: Nature, Commodity Chains, and the Place of Tibet in China's Uneven Geographies," *Social & Cultural Geography* 14 (2013): 318–40.

[30] *Zhongguo Tongyou Difang Wuchanzhi* (cit. n. 26), 607, 662.

[31] Hu Anbang, *Shiyong Yaoxing Zidian* (Shanghai: Zhongyang Shudian, 1935), 40. One jin was then equal to 500 grams.

[32] *Shanghai Jiefang Qianhou Wujia Ziliao Huibian (1921–1957)* (Shanghai: Shanghai Renmin Chubanshe, 1958), 217.

[33] For examples, see "Jinsannian Xikang Shexiang Chongcao Chukou Tongji," *Guoji Maoyi Qingbao* 1 (1936): 74; Zhuang Xueben, *Qiangrong Kaochaji* (Shanghai: Liangyou Tushu Yinshua Gongsi, 1937), 127–8; "Chuanxi Diaochaji," in *Zhongguo Bianjiang Shehui Diaocha Baogao Jicheng*, collection 1, book 5 (1941; repr., Guilin: Guangxi Shifan Daxue Chubanshe, 2010), 494–5; and Long Yun, *Xinzuan Yunnan Tongzhi*, book 4 (1944; repr., Kunming: Yunnan Renmin Chubanshe, 2007), 126–9.

[34] "Benshi Guoyao Zhangchao Fanlan," *Zhengxin Xinwen* 646 (1947): 7.

[35] "Changdu Gelunlalu Gaoshi Xiaochu Zangkang Liangzu Jiexian," *Shenbao*, 23 November 1948, section 2.

[36] Kelly A. Hopping, Stephen M. Chignell, and Eric F. Lambin, "The Demise of Caterpillar Fungus in the Himalayan Region due to Climate Change and Overharvesting," *PNAS* 115 (2018): 11489–94.

[37] Fan Yajun, "Zibu Yu Jiankang: Shenbao Buyao Guanggao De Shehui Wenhuashi Yanjiu, 1873–1945" (master's thesis, Nanjing University, 2012), 14–36.

used the caterpillar fungus in medical treatments in late Qing China, merchants also explored its commercial value by developing new products.[38] In the Republican period, the caterpillar fungus continued to be sold in drugstores in Suzhou and other domestic and overseas cities.[39] By the 1930s, it had become a staple product of today's eastern Tibet and western Sichuan, finding much favor with wealthy people in Guangdong, Fujian, Shanghai, and Nanjing, despite its high price.[40] The value of the caterpillar fungus was greatly exploited in Shanghai, the commercial capital of China. The food company Guanshengyuan, for example, once advertised its new tonic food called the caterpillar fungus-duck on New Year's Day, 1925.[41] Some shrewd restaurants also served tonic dishes involving the use of the caterpillar fungus, such as *chongcao ruge* (caterpillar fungus-young pigeon).[42] These dishes count as variations on the caterpillar fungus-duck combination described by Parennin about two centuries earlier. Some gourmets actively introduced the recipes for these dishes to the public. One of them promoted such a recipe with additional reference to the magical transformation of the caterpillar fungus (from a blade of grass to a worm), and a premodern medical record of its potency, in the journal *Changshou* (Longevity), published in Shanghai.[43] Even in 1946, the latest guidebook to Shanghai listed the duck stewed with the caterpillar fungus as a famed tonic dish produced in local Sichuan-style restaurants and allegedly only sold to frequent customers.[44]

So profitable and popular was the caterpillar fungus that some speculative merchants began to sell it even though it was beyond the scope of their original business. For example, a snow fungus (*Tremella fuciformis*) company in Shanghai advertised on 4 January 1928 that it sold not only the snow fungus, but medicinal substances and tonics such as the caterpillar fungus.[45] In another advertisement on 23 September of the same year, a Sichuan store in Shanghai claimed it also sold the caterpillar fungus and some other specialist products of Sichuan.[46] It is worth adding here that the *guohuo* (national products) movements prospering in Republican China and delivered in highly nationalistic and anti-imperialist tones were infused with propaganda about how the products could benefit national economic interests.[47] Against this background, the

[38] For examples, see Wang Shixiong, "Suixiju Chongding Huoluanlun," in *Wangmengying Yixue Quanshu*, ed. Sheng Zengxiu (1862; repr., Beijing: Zhongguo Zhongyiyao Chubanshe, 1999), 173; Zhang Naixiu, *Zhangyuqing Yi'an* (ca. 1905; repr., Shanghai: Shanghai Kexue Jishu Chubanshe, 1963), 128–9; "Jishou Chongcaogao," *Shenbao*, 19 December 1881, section 6; and "Shenqi Chongcaogao," *Shenbao*, 7 November 1884, section 6.

[39] Curtis G. Lloyd, "Cordyceps sinensis, from N. Gist Gee, China," *Mycological Notes* 54 (1918): 766–80; "Xuzhongdao Guoyao Zongfenhao Shijia Lianhe Jintian Dajianjia," *Shenbao*, 30 September 1932, section 17.

[40] "Xikang 'Chongcao' Chukou Jushu," *Fangzhou* 12 (1934): 12; Ran, "Chongcao," *Shusheng Zhoubao* 51 (1937): 16.

[41] "Xinfaming Dongchongcaoya Shangshi," *Shenbao*, 1 January 1925, section 19.

[42] See, for examples, "Nanyuan Jiujia," *Shenbao*, 16 November 1928, section 21; "Weiya Jiulou Xinfengji Shangshi," *Shenbao*, 21 September 1929, section 16; and "Yanhualou Jiujia Zhi Zibu Dunpin," *Shenbao*, 1 November 1929, section 25.

[43] Shen Xi, "Dongchong Xiacao Weiya," *Changshou* 144 (1935): 350.

[44] Leng Xingwu, *Zuixin Shanghai Zhinan* (Shanghai: Shanghai Wenhua Yanjiushe, 1946), 107.

[45] "Shutongsen Yinerzhuang Jianjia Zhanqi," *Shenbao*, 4 January 1928, section 21.

[46] "Sichuan Shangdian (Yizhou Jinian) Yiner Dajianjia," *Shenbao*, 23 September 1928, section 13.

[47] Karl Gerth, "Consumption as Resistance: The National Products Movement and Anti-Japanese Boycotts in Modern China," in *The Japanese Empire in East Asia and its Postwar Legacy*, ed. Harald Fuess (Munich: Iudicium, 1998), 119–42; Gerth, *China Made: Consumer Culture and the Creation of the Nation* (Cambridge, Mass.: Harvard Univ. Press, 2003), 125–202.

largest national products exhibition held in China at that time took place in Shanghai between 1 November 1928 and 3 January 1929. Two official representatives of Sichuan and Yunnan promoted the caterpillar fungus among visitors as one of their most prized local medicinal products.[48] As the consumer market for the caterpillar fungus was not confined to China, a company that was probably hoping to expand its overseas market advertised its caterpillar fungus stocks and futures in the weekly for Shanghai's Consulting Institute for International Trade on 20 June 1946.[49]

The persistent circulation of the esteemed caterpillar fungus is a perfect example of the dynamic production and consumption of local medicinal and edible products in Republican China. Despite the Nationalist government imposing certain legal restrictions on the sale and use of Chinese medicinal substances, there was a substantial gap between expectation and realization before the outbreak of the full-scale Sino-Japanese War in 1937, due to the resistance of medicine merchants, local governments' dereliction of duty, and such.[50] During the war, the Nationalist government had temporarily softened the restrictions, mainly because of medication shortages.[51] Meanwhile, the Communist regime encouraged the employment of both native and imported medicinal substances in its wars with the Japanese army and the Nationalist government.[52] These circumstances, together with the power of tradition, ensured the ongoing use of Chinese medicinal substances. Traditional physicians continued to apply the caterpillar fungus in their medical practices.[53] Indigenous knowledge about the caterpillar fungus and many other medicinal substances also circulated through a variety of medical and popular publications and schools, and persisted throughout the Republican period.[54] Moreover, many medicinal substances, like the caterpillar fungus, could

[48] Dong Shaoshu, "Zhonghua Guohuo Zhanlanhui: Dong Shaoshu Zhi Yanci," *Shenbao*, 26 December 1928, section 14; Li Kuian, "Zhonghua Guohuo Zhanlanhui: Sichuan Daibiao Li Kuian Zhi Baogao," *Shenbao*, 29 December 1928, section 13. More than ten thousand invited guests and fifty thousand tourists attended the exhibition; see Hong Zhenqiang, "1928 Nian Zhonghua Guohuo Zhanlanhui Lunshu," *Huazhong Shifan Daxue Xuebao (Renwen Shehui Kexueban)* 45 (2006): 83–8.

[49] Guoji Maoyi Zixunsuo, "Chukou Xiaoxi," *Jinchukou Maoyi Xiaoxi* 122 (1946): 1.

[50] Di Lu, "Minguo Shiqi Yaoshang He Putong Yaopin Guanli Fagui De Zhiding Yu Tuixing," *Jindai Zhongguo* 27 (2017): 77–102.

[51] Wen Xiang, *Yizhi Yu Chaoyue: Minguo Zhongyi Yizheng* (Beijing: Zhongguo Zhongyiyao Chubanshe, 2007), 102–8.

[52] Yang Lisan, "Di Shiba Jituanjun Yezhan Houqinbu Yang Lisan Buzhang Zai Yaoping Cailiaochang Gongzuo Huiyi Shang De Zongjie," in *Liudeng Dajun Weisheng Shiliao Xuanbian*, ed. He Zhengqing (1941; repr., Chengdu: Chengdu Keji Daxue Chubanshe, 1991): 27–30; Jin Jin, ed., *Zhongguo Renmin Jiefangjun Yaocai Gongzuo Shi* (Beijing: Zong Houqin Bu Weisheng Bu, 1997), 29–32, 66–7, 119, 151; John R. Watt, *Saving Lives in Wartime China: How Medical Reformers Built Modern Healthcare Systems amid War and Epidemics, 1928–1945* (Leiden: Brill, 2013), 77–95.

[53] Lu Jinsui, *Jingjing Yihua* (1916; repr., Taiyuan: Shanxi Kexue Jishu Chubanshe, 1999), 1382; Ding Ganren, *Ding Ganren Yi'an* (1927; repr., Shanghai: Shanghai Kexue Jishu Chubanshe, 1960), 106; Qin Bowei, *Qianzhai Gaofangan* (1938; repr., Fuzhou: Fujian Kexue Jishu Chubanshe, 2007), 43; Shi Jinmo, *Zhuxuan Shi Jinmo Yi'an* (1940; repr., Beijing: Huaxue Gongye Chubanshe, 2010), 46–7.

[54] For indigenous knowledge about the caterpillar fungus in Republican medical texts, see, for examples, Wenming Shuju, *Yaoxing Yizhi* (Shanghai: Wenming Shuju, 1919), 9; Xie Guan, *Zhongguo Yixue Dacidian* (Shanghai: Shangwu Yinshuguan, 1921), 668–9; Hu Fangxi, "Zengbu Bencaoshi: Dongchong Xiacao," *Zhongyi Zazhi* 16 (1925): 7; Lu Peng, *Yaowuxue Jiangyi* (ca. 1929; repr., Beijing: Zhongguo Zhongyiyao Chubanshe, 2016), 23; Weisheng Baoguan, *Zhongyao Dacidian* (Shanghai: Weisheng Baoguan, 1930), 86; Zhang Shanlei, *Bencao Zhengyi* (1932; repr., Fuzhou: Fujian Kexue Jishu Chubanshe, 2015), 102–3; Hu, *Shiyong Yaoxing Zidian* (cit. n. 31), 40; "Daodi Yaocai," *Liangyou* 158 (1940): 12; Cai Luxian, *Zhongguo Yiyao Huihai*, book 1 (Shanghai: Zhonghua Shuju, 1941), 537; and Zhou Zhilin, *Bencao Yongfa Yanjiu* (1941; repr., Shanghai: Zhonghua Shuju, 1948), 756–7. The Shanghai Specialist School of Chinese Medicine (1916–48) is a representative school that

be used as food or as culinary ingredients, and thereby could circumvent the state regulation mentioned above, just as happens in Europe and China today.

Following the Communist victory, under particular political, social, and economic conditions, Chinese medicine began to enjoy a much higher social standing than it had in the Republican period.[55] Traditional understanding of the caterpillar fungus continued, and appeared in, for example, the 1963 Chinese national pharmacopeia.[56] In 1953, Chairman Mao had also presented some caterpillar fungus as a gift to a teacher he had once had.[57] In some cities of early Communist China, like Chongqing, the dish known as steamed duck with caterpillar fungus featured in the celebrated local cuisine.[58]

CHANGING PERCEPTIONS OF THE CATERPILLAR FUNGUS IN NINETEENTH-CENTURY JAPAN

The flourishing of European natural history in Japan's Edo and Meiji periods boosted new passions for observing, describing, and collecting native or exotic natural objects.[59] The Linnaean classification system, beginning to take root in Japan in the early nineteenth century, also prompted the equivalence between some East Asian and European scientific (Latin) names for indigenous organisms.[60] As the caterpillar fungus continued to be exported to Japan and sold in Japanese drugstores in the early nineteenth century, some local naturalists and physicians were no longer satisfied with learning about it from previous Chinese and Japanese records.[61] They sought to discover this natural curiosity in their own country, though it did not inhabit Japan and hence had never been found there. But this trend led to new natural history discoveries and reflections in the encounter between East Asian and European academic traditions. In his 1801 collection of drawings, the physician Yuzuki Tokiwa grouped the caterpillar fungus from China together with some similar insect-fungi growing in Japan under the name of kasō tōchū; he illustrated their different morphological characteristics and particularly recorded the former as imported.[62] Federico Marcon points out that by the late Edo period, "accurate and detailed illustrations of plants and animals developed as a new cognitive apparatus to identify species and solve the old

devoted itself to education in Chinese medicine in the Republican era. For the history of this school, see *Mingyi Yaolan: Shanghai Zhongyi Xueyuan (Shanghai Zhongyi Zhuanmen Xuexiao) Xiaoshi* (Shanghai: Shanghai Zhongyiyao Chubanshe, 1998).

[55] Kim Taylor, *Chinese Medicine in Early Communist China, 1945–63* (London: RoutledgeCurzon, 2005), 30–62, 151–3.

[56] Weishengbu, *Zhonghua Renmin Gongheguo Yaodian* (Beijing: Renmin Weisheng Chubanshe, 1964), 77.

[57] Li Shuntong, *Daifang Shuwu Wenji* (Xiangtan: Xiangtan Daxue Chubanshe, 2013), 207.

[58] Chongqingshi Yinshi Fuwu Gongsi, *Chongqing Mingcaipu* (Chongqing: Chongqing Renmin Chubanshe, 1960), 38–9.

[59] Nishimura Saburo, *Bunmei No Naka No Hakubutsugaku: Seiō to Nihon*, vol. 1 (Tokyo: Kinokuniya Shoten, 1999), 129–35; Itō Mamiko, "19 Seikinihon No Chi No Chōryū: Edo Kōki ~ Meiji Shoki No Hakkajiten, Hakubutsugaku, Hakurankai," *19 Seikigaku Kenkyū* 6 (2012): 59–78; Jung Lee, "Provincialising Global Botany," in *Worlds of Natural History*, ed. Helen A. Curry, Nicholas Jardine, James A. Secord, and Emma C. Spary (Cambridge: Cambridge Univ. Press, 2018), 433–46.

[60] Itō Keisuke, "Tōyō Shokubutsugaku No Ichi Daikaikaku Wonasazaruka Karazu," *Shokubutsugaku Zasshi* 19 (1888): 177–81; Kitamura Siro, "The Japanese Studies on the Chinese Plants," *Acta Phytotaxonomica et Geobotanica* 1 (1989): 119–22.

[61] Fujii Kansai, *Zōho Shuhan Hatsumō* (Tokyo: Yamashiroya Sahei, 1829), 347–50.

[62] Yuzuki Tokiwa, *Hakurai Kasōtōchū Zu* (Tokyo: National Diet Library, 1801), 2–13.

problem of matching Chinese names with actual plants and animals."[63] Yuzuki's drawing and his use of the Japanese term kasō tōchū, which contains the same two pairs of characters in the Chinese term xiacao dongchong (summer grass winter worm), also contributed to the solving of the "old problem" of matching Chinese names with actual organisms. But for the Japanese, kasō tōchū broadly denoted a group of insect-fungi rather than merely the caterpillar fungus.

Yuzuki's record received attention from the herbalist Ohara Momohora (1746–1825), who learned about the geographical origin and medicinal properties of the caterpillar fungus from some Japanese and Chinese accounts. He agreed with Yuzuki that similar organisms grew in Japan, as some Japanese publications had reported discoveries of such organisms around ditches and courtyards in 1805, 1808, and 1824. In his posthumous manuscript, which contains illustrations of eleven specimens of such native organisms, Ohara suspected that some of the insect-fungi found in Japan were *semihana* (*chanhua* in Chinese, which literally means flowers on cicada); this was a medicinal substance that had long been used in China.[64] Another herbalist, named Mizutani Toyofumi (1779–1833), once also depicted specimens of such insect-fungi, or "flowers on cicada," in his drawings of insects and animals.[65] The specimens mainly differ from each other in the morphological characteristics of their fruiting bodies. From the early nineteenth century to the early twentieth century, discoveries of insect-fungi were occasionally being made in Japan.[66] Meanwhile, the term kasō tōchū, or its inverted form tōchū kasō of Chinese origin, was also often used in a broadened sense to denote insect-fungi in relevant Japanese publications.[67] To differentiate it from its Chinese homonym, some Japanese authors accentuated the geographical origins of the organisms in question when they used the terms. For example, Fujii Kansai stated that he had seen both the Chinese caterpillar fungus sold in Japanese drugstores and similar organisms native to Japan. The entry for tōchū kasō in his 1829 text on materia medica explicitly identifies two kinds of such organisms: one is *hakurai* (imported), while the other is *kazusan* (produced in Japan).[68]

However, hakurai is an ambiguous expression, because it does not specify where the caterpillar fungus was imported from. In the late nineteenth and early twentieth centuries, some Japanese scientists began to use the more specific term *kansan* or *shinasan* (produced in China) to refer to the caterpillar fungus from China, or C*ordyceps sinensis* or *Sphaeria sinensis*.[69] Clearly, the attempts to seek a "Japanese" caterpillar fungus coincided with reflections on new relationships between names and entities. The discoveries of similar organisms in Japan also presented new findings on the

[63] Marcon, *The Knowledge of Nature* (cit. n. 14), 228.

[64] Ohara Momohora, *Momohora Ihitsu*, vol. 3 (Wakayama: Sakamotoya Kiichirō, 1833), 29–36.

[65] Mizutani Toyofumi, *Mushimujina Shashin* (Tokyo: National Diet Library, ca. 1833), 88–90. However, Mizutani's drawings of the insect-fungi lack captions.

[66] Ezaki Teizō, "Fukuoka Agata Yamegun San Kasō Tōchū Nijute," *Kyushu Teikuni Daigaku Nōgakubu Gakugei Zatsushi* 3 (1929): 221–31.

[67] For example, see Oda Seisuke, "Tōchū kasō," *Konchū Sekai* 2 (1898): 465.

[68] Fujii, *Zōho Shuhan Hatsumō* (cit. n. 61), 347–8.

[69] Kurita Manjirō, "Zoku Shina Hakubutsu Ikō (Shōzen)," *Tōkyō Chigaku Kyōkai Hōkoku* 11 (1889): 29–32; Shirai Mitsutarō, *Shokubutsu Yōikō* (1914; repr., Tokyo: Oka Shoin, 1925), 364–6. At the beginning of the twenty-first century, the Japanese scholar Okuzawa Yasumasa uses the word *kōgi* (broad sense) as an addition to the term tōchū kasō, serving the purpose of disambiguation; see Okuzawa Yasumasa, "Tōchū Kasō (Kōgi) Torai No Rekishi To Yakubutsu To Shite No Juyō," *Nihon Ishigaku Zasshi* 53 (2007): 178–9.

geographical distribution of insect-fungi. The transformation of the Chinese term xiacao dongchong, or dongchong xiacao, to the Japanese term kasō tōchū, or tōchū kasō, together with the broadened meaning of its identifications in the Japanese context, point to the semantic boundaries of the same word, and indicate a Japanization of the category for the Chinese caterpillar fungus. This accords with Benjamin A. Elman's analysis of the adaptation of Chinese medicine and appropriation of Chinese thoughts and learning before the late nineteenth century in Japan.[70] The altered category crossed the boundary between the caterpillar fungus and other insect-fungi. It also counts as a response to European natural history, because it could accommodate European natural knowledge about the fungi parasitic on insects.

The introduction of scientific information on insect-fungi testifies to European influence and to a pluralistic understanding of such organisms in nineteenth-century Japan. Even in the late nineteenth century, some Japanese still supported the transformation theory of the caterpillar fungus, and/or applied the theory to native insect-fungi.[71] Nevertheless, since the early nineteenth century, some Chinese knowledge about the caterpillar fungus had become a target for criticism. The naturalist Masushima Ranen mentioned this organism in his 1811 book on fungi. He related the "grass" to *kin* (fungi) and emphasized that the formation of the "winter worm summer grass" was absolutely not caused by the extremely absurd transformation, but by fungal infections of dead insects underground. Still, he valued Chinese medical knowledge about the caterpillar fungus, and suggested not abandoning it with the fallacious transformation theory. This concern for medical utility explains why he particularly quoted a related Qing Chinese medical record.[72] Some late nineteenth-century Japanese botanical and entomological articles also sometimes set out to inform readers about the true nature of the caterpillar fungus and similar organisms. For example, stimulated by an inquiry about the caterpillar fungus and its transformation, Miyoshi Manabu, then studying botany at the Imperial University of Tokyo, published a review article in *Shokubutsugaku Zasshi* (The Botanical Magazine) in 1888.[73] He aimed to help readers abandon their belief in fallacious ideas. After quoting Ohara's account, he turned to a few Chinese and English publications, including Mordecai C. Cooke's mycological monograph.[74] Miyoshi treated tōchū kasō as a taxonomic group of organisms, and enumerated nine species of fungi belonging to the genus *Torrubia*. According to the article, twenty-five species of the insects on which these fungi grew, such as *Hepialus virescens*, had been discovered; and both the insects and fungi were distributed around the world. With this assertion, the caterpillar fungus not only lost its ability to transform, but also lost its value as being a rare fungus.

[70] Benjamin A. Elman, "Sinophiles and Sinophobes in Tokugawa Japan: Politics, Classicism, and Medicine during the Eighteenth Century," *East Asian STS* 2 (2008): 93–121.

[71] For example, see Umeno Takizō and Mitani Yūshin, *Chikugo Chishi Ryaku* (Kurume: Kinbundō, 1879), 45.

[72] Shirai, *Shokubutsu Yōikō* (cit. n. 69), 361–2.

[73] Miyoshi Manabu, "Tōchū Kasō No Ben," *Shokubutsugaku Zasshi* 2 (1888): 36–40. For a brief chronicle of Miyoshi's life, see Andou Yutaka, "Shokubutsu Gakusha Miyoshi Manabu Kenkyū Shiryō: IV," *Kiyoizumi Jogakuin Tankidaigaku Kenkyū Kiyō* 13 (1995): 67–90.

[74] This monograph is *Fungi: Their Nature, Influence, and Uses*, which, however, had been published in different editions before 1888. For the original account in its first edition, see Mordecai Cubitt Cooke, ed. Miles Joseph Berkeley, *Fungi: Their Nature, Influence, and Uses* (London: Henry S. King, 1875), 246–7.

A few years later, in 1894, Yasuda Atsushi, a botany student at the Imperial University of Tokyo, reported his identifications of two species of parasitic fungi.[75] One was "*Isaria arachnophila*, Ditm.," found growing on a trapdoor spider; the other was "*Torrubia militaris*, Fr.," found growing on some species belonging to the order Lepidoptera. Yasuda discovered them in Japan, and generally called them tōchū kasō. Like Miyoshi, he criticized the transformation theory as a fallacy, though the emphasis of his articles was on macroscopic and microscopic descriptions of the specimens, which were given to support his identifications. He employed mycological terms to describe their morphological structures, such as *shijitsutai* (stroma), *hōshi* (spore), *kinshi* (mycelium), and *hachiretsushi* (ascospore).[76] Besides, he also used the characters such as *ka* (family), *zoku* (genus), and *tane* (species) to describe their taxonomic ranks. The concept of species and taxonomic hierarchy, and the application of microscopic observation in identifying species, doubtless originated in modern European biology. In his articles, the two specimens had formed as follows: fungal spores infected underground insects, developed into mycelium inside the insects, and eventually killed them; after having occupied the interior of the dead insect bodies, the mycelium then grew out of the bodies and formed visible fruiting bodies. Yasuda's identifications and theoretical explanations of the formation of the fungi embody the tensions between East Asian and European perceptions of nature. In particular, the microscope, which spoke for the epistemic virtue of what Lorraine Daston and Peter Galison call "mechanical objectivity," enabled Japanese biologists to "see" inaccessible and invisible regions of nature.[77] The power of new scientific instruments (e.g., the microscope and telescope), perceived by modern Europeans as "evidence of the superiority of their age over antiquity," and aiding "fresh and truthful observations," was also adopted into the powerful rhetoric of modern science in Japan.[78]

Like Miyoshi and Yasuda, Oda Seisuke, who had been trained at an agricultural school, also criticized the old transformation theory in his short, exoteric article about the diversity of native insect-fungi. The article, directly entitled "Tōchū Kasō," and published in the magazine *Konchū Sekai* (Insect world) in 1898, introduces the biological nature, taxonomic positions, and habitat of insect-fungi, and gives a scientific explanation of their formation.[79] In contrast, an 1889 article by the naturalist Kurita Manjirō primarily focuses on the caterpillar fungus. But Kurita also associated it with similar Japanese insect-fungi, and still called the latter kasō tōchū.[80] Kurita first wrote of its fungal nature, its identity as a famous Chinese medicinal substance, and its

[75] Yasuda Atsushi, "Chitsutō Ni Kisei Suru Tōchūkasō Ni Ju Te," *Shokubutsugaku Zasshi* 8 (1894): 337–40; Yasuda, "'Kisa Nagi Take' (Tōchū Kasō No Isshu) Torrubia militaris, Fr.," *Shokubutsugaku Zasshi* 8 (1894): 410–11. Yasuda graduated from the university in 1895; see *Imperial University of Tōkyō: The Calendar* (Tokyo: Imperial University, 1898): 333.

[76] The English terms "stroma" and "ascospore" are not my own translations but are directly cited from Yasuda's articles.

[77] Lorraine Daston and Peter Galison, *Objectivity* (New York, N.Y.: Zone Books, 2007), 115–90.

[78] Albert Van Helden, "The Birth of the Modern Scientific Instrument, 1550–1770," in *The Uses of Science in the Age of Newton*, ed. John G. Burke (Berkeley and Los Angeles: Univ. of California Press, 1983), 65; Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science* (Baltimore: Johns Hopkins Univ. Press, 2005), 187.

[79] Oda Seisuke, "Tōchū Kasō," *Konchū Sekai* 2 (1898): 465. For Oda's educational background, see "Daiichikai Zenkuni Gaichū Kujo Shūgyōsei Seimei," *Konchū Sekai* 3 (1899): 397–8.

[80] Kurita Manjirō, "Zoku Shina Hakubutsu Ikō (Shōzen)," *Tōkyō Chigaku Kyōkai Hōkoku* 11 (1889): 29–32.

scientific name by referring to John Lindley's *The Vegetable Kingdom* (1853). Then he quoted related records from three materia medica texts in the English, Chinese, and Japanese languages respectively.[81] The popular transformation theory did not receive his direct criticism. And Kurita seemed to avoid acting as a judge of true or fallacious knowledge, rather endeavoring to tolerate and bring together knowledge from different cultures. However, the terms "Sphaeria Sinensis, Berk." and "*kinzoku*" (fungi) introduced at the beginning of the article already indicated the priority of European scholarship on the natural properties of the caterpillar fungus in his mind.

THE SHAPING OF A SCIENTIFIC CATERPILLAR FUNGUS IN REPUBLICAN CHINA

After receiving the caterpillar fungus as a gift from one of his Sichuan friends, along with advice on its culinary and medical purposes, the Confucian scholar Yu Yue (1821–1907), a native of Zhejiang, praised it as a *lingyao* (panacea), with the ability to transform between a winter worm and a summer grass, and to exist beyond life and death.[82] Chinese literati lamented and extolled the virtues of the caterpillar fungus in this way and associated it with their personal experiences and reflections on the potency and immortality of their culture.[83] From the beginning of the twentieth century, however, challenges to previous narratives of the caterpillar fungus began to appear in China.

Humiliated by defeat in the Sino-Japanese War (1894–95), Chinese central and provincial governments "sought Japanese expertise on topics relating to modernization," such as finance, science, education, and engineering; and "for most Chinese, Japanese imperialism was not yet seen as a problem."[84] Education in China underwent profound transformation in the 1900s. By 1905, as Benjamin A. Elman indicates, "the new Qing Ministry of Education was staunchly in favor of science education and textbooks based on the Japanese scientific system"; and the *Nongxue Bao* (Journal of Agriculture, Shanghai), published from 1897 to 1906, was among the many periodicals and books that mediated "Japanese-style science and technology" for the Chinese.[85] In August 1900, the Japanese sinologist Fujita Toyohachi published a Chinese translation of Oda Seisuke's 1898 article on tōchū kasō in *Nongxue Bao*.[86] It propagated new and disenchanted natural knowledge about insect-fungi among the

[81] The three texts are Frederick Porter Smith's *Contributions towards the Materia Medica & Natural History of China* (London: Trübner, 1871), Zhao Xuemin's *Bencao Gangmu Shiyi* (Qiantang: first printed by Zhang Yingchang, finalized ca. 1803), and Fujii Kansai's *Zōho Shuhan Hatsumō* (Edo: Yamashiroya Sahei, 1829). Kurita recorded the title and the author of the English book as *Shina Yakuhin Bikō* and Sumisu (a Japanese transliteration of the English word "Smith"). Besides, Kurita added that he referred to the seventy-third page of Smith's text. These clues, together with the content of the quotation, lead us to Frederick Porter Smith's 1871 book on materia medica and natural history.

[82] Yu Yue, "Chunzaitang Shibian," in *Xuxiu Siku Quanshu*, book 1551, ed. Gu Tinglong (1899; repr., Shanghai: Shanghai Guji Chubanshe, 2002), 559.

[83] For examples, see Zhang Weiping, "Guochao Shiren Zhenglue," in *Xuxiu Siku Quanshu*, book 1713, ed. Gu Tinglong (1819; repr., Shanghai: Shanghai Guji Chubanshe, 2002), 1–401, on 3; Zhang Shu, "Suyangtang Shiji," in *Xuxiu Siku Quanshu*, book 1506, ed. Gu Tinglong (1842; repr., Shanghai: Shanghai Guji Chubanshe, 2002), 119–415, on 270; and Fan Xinghuan, "Cao Fugu Dongchong Xiacao Shi," *Shaoxing Yiyao Xuebao* 32 (1910): 9.

[84] June T. Dreyer, *Middle Kingdom and Empire of the Rising Sun: Sino-Japanese Relations, Past and Present* (Oxford: Oxford Univ. Press, 2016): 53.

[85] Benjamin A. Elman, "Toward a History of Modern Science in Republican China," in *Science and Technology in Modern China, 1880s–1940s*, eds. Jing Tsu and Benjamin A. Elman (Leiden: Brill, 2014): 15–38, on 27–9.

[86] Oda Seisuke, "Dongchong Xiacao," trans. Fujita Toyohachi, *Nongxue Bao* 114 (1900): 484–5.

Chinese. But the title, *Dongchong Xiacao*, would lead readers to think it was about the caterpillar fungus consumed in Chinese society. Fujita was employed in Shanghai until 1919 by a founder of *Nongxue Bao* to translate Japanese sources for the journal, which, established against the background of a social movement directed at modernizing Chinese agriculture, placed emphasis on both classical Chinese agricultural knowledge and newer European, American, and Japanese agriculture and applied sciences.[87] In view of the emphasis of the journal, Fujita's translation actually digressed from the journal's object, though in two later translations he focused on parasitic insects and toads, both highly relevant to crop protection.[88] It is reasonable to speculate about Fujita's possible intention of overturning the long prevailing stories of the caterpillar fungus's magical transformation and treating this organism instead as an ordinary example of an insect-fungi.

Three years later, in 1903, *Nongxue Bao* published a relatively long translation entitled *Dongchong Xiacao Shuo* (On winter worm summer grass), which was originally written by the Japanese botanist Itō Tokutarō (1866–1941).[89] The translation starts with a discussion of more than ten specimens of the caterpillar fungus brought from Tibet to Japan by the Buddhist monk Kawaguchi Ekai (1866–1945), who then presented them to Itō for identification. Itō described the appearance of these specimens, explained the life cycle as an irreversible process of fungal infection, and then succinctly reviewed the history of European studies of this species. But he further stressed that sixty-two such fungal species had been discovered around the world. Like Oda or Fujita, he treated dongchong xiacao or tōchū kasō as a group of insect-fungi rather than a single species, and claimed the existence of similar species native to Japan. Besides the caterpillar fungus, Kawaguchi also presented Itō with some plants collected in Sikkim Himalaya.[90] Itō seemed to have a greater interest in the caterpillar fungus, since he wrote an article exclusively on it. His intention, as indicated in the article, was to expose the errors of the popular old theory of its formation, so that, now the scientific theory of its life cycle had become clear, people should not continue to believe the erroneous theory.

Following the publication of such articles and popularizations of scientific knowledge, Chinese intellectuals also gradually engaged in the dissemination of new facts about the caterpillar fungus. In 1905, a Chinese author published his translation of the last chapter of Miyoshi Manabu's book *Shokubutsugaku Jikken Shoho* (Introduction to botanical experiments, 1899) in *Nüzi Shijie* (The female world), a journal dedicated to female education and women's rights.[91] The chapter gave an outline of nineteenth-century European classification of flowering, flowerless, and seedless plants,

[87] Zhang Kai, "Wunonghui, Nongxue Bao, Nongxue Congshu Ji Luo Zhenyu Qiren," *Zhongguo Nongshi* 1 (1985): 82–8; Douglas R. Reynolds, *China, 1898–1912: The Xinzheng Revolution and Japan* (Cambridge, Mass.: Harvard Univ. Press, 1993): 116; Li Yongfang, "Tengtian Fengba: Qingmo Xifang Nongxue Yinjin De Xianxingzhe," *Shehui Kexue* 8 (2012): 142–9.

[88] "Jishengchong Baohuqi," trans. Fujita Toyohachi, *Nongxue Bao* 114 (1900): 485; "Ji Chanchu," trans. Fujita Toyohachi, *Nongxue Bao* 114 (1900): 485–6.

[89] Itō Tokutarō, "Dongchong Xiaocao Shuo," trans. unknown, *Nongxue Bao* 231 (1903): 440–4.

[90] Itō Tokutarō, "Notes on Some Himalayan Plants Collected by the Rev. Keikai Kawaguchi in 1902," *Botanical Magazine* 17 (1903): 157–9.

[91] Miyoshi Manabu, "Zhiwuyuan Goushefa," trans. Zhiqun, *Nüzi Shijie* 3 (1905): 21–6; Manabu, "Zhiwuyuan Goushefa (Continued)," trans. Zhiqun, *Nüzi Shijie* 6 (1905): 31–46; compare these to Manabu, *Shokubutsugaku Jikken Shoho* (Tokyo: Keigyōsha, 1899), 134–41. For the objective of the journal, see Jin Songcen, "Nüzi Shijie Fakanci," *Nüzi Shijie* 1 (1904): 1–3.

in which the caterpillar fungus was listed as a representative species of the ascomycetes fungi. In 1913, a set of short articles by Ya Bo, who was studying at the College of Agriculture, Imperial University of Tokyo, appeared in the *Kexue Conghua* (Collected narratives of science) column of *Datong Zhoubao* (Great harmony weekly, Shanghai). The first of these articles deals with the *zhenxiang* (truth) about the caterpillar fungus.[92] Ya Bo wrote that scientific investigation revealed the mycelial infection of underground butterfly larvae was the true reason for the formation of the caterpillar fungus, as well as *jinchanhua* (golden flowers on cicada, an insect-fungus). To reinforce the authenticity of this new scientific explanation, he mentioned the microscope and encouraged readers interested in natural history to carry out microscopic observations. Such a statement obviously indicated the discursive power of microscopy.

The Republican period witnessed the increasing impact of scientific discourse on the Chinese intellectual community. The entry for dongchong xiacao in the first edition of *Ciyuan* (Origins of [Chinese] terms, 1915), also the first modern Chinese comprehensive encyclopaedia, deals only with fungi, insects, and parasitism, totally ignoring premodern Chinese accounts.[93] This is consistent with one of the main principles for its compilation, which was scientism in the conceptualization of natural objects and phenomena.[94] The illustration in the entry shows the fungus growing out of a mature insect rather than a larva. This indicates that dongchong xiacao in the entry does not refer to the Chinese caterpillar fungus (*Cordyceps sinensis*) but some other insect-fungi, which also reflects the influence of Japanese scholarship.[95] Moreover, a 1928 illustrated popular science article on the caterpillar fungus, aimed at children, not only mentions other insect-fungi but also denies the reality of transformation between different species.[96] Pan Jing, who had studied in France at the end of the 1900s, introduced the caterpillar fungus as a famous Sichuan foodstuff, and additionally invoked related biological research in his 1931 book.[97] Lu Wenyu's 1932 article in the *Guangzhi Xingqibao* (Weekly for spreading wisdom) refutes traditional ideas of the oddities of the caterpillar fungus by referring to Matsumura Jinzō's *Shokubutsu Meii* (Collection of botanical terms), Nishimura Suimu's *Semi No Kenkyū* (A study of cicada), and Adolf Engler's system of plant classification. It also mentions a few other fungal species of the genus *Cordyceps*, the medical and culinary uses of the caterpillar fungus, and his brother's experience of eating steamed caterpillar fungus in Sichuan.[98] Quite a number of articles exemplifying scientific authority involved in perceiving the caterpillar fungus were published.[99] But modern science did not enjoy superiority over, for example, the culinary preparation, edibility, and medicinal properties of the fungus.

[92] Ya Bo, "Dongchong Xiacao Zhi Zhenxiang," *Datong Zhoubao* 2 (1913): 1.
[93] Lu Erkui, ed., *Ciyuan* (Shanghai: Shangwu Yinshuguan, 1915), 303.
[94] Wang Jiarong, "Ciyuan, Cihai De Kaichuangxing," *Cishu Yanjiu* 4 (2010): 94, 130–40.
[95] The entry also says that the infected insects include the *lougu* (mole cricket), which *Cordyceps sinensis* actually does not infect.
[96] Ren Shou, "Dongchong Xiacao," *Ertong Shijie* 22 (1928): 33–6.
[97] Pan Jing, *Qiaoshan Zazhu* (n.p.: privately printed, 1931), 131. For Pan's educational experience in France, see Wang Huanchen, ed., *Liuxue Jiaoyu: Zhongguo Liuxue Jiaoyu Shiliao*, book 2 (Taipei: Guoli Bianyiguan, 1980), 631, 688–9.
[98] Lu Wenyu, "Xinnong Jianwen Suibi," *Guangzhi Xingqibao* 154 (1932): 4–6.
[99] For examples, see "Dongchong Xiacao Jiujing Shi Shenme Dongxi," *Xiao Pengyou* 569 (1933): 39; "Dongchong Xiacao," *Zhishi Huabao* 4 (1937): 26–7; Zhu Peiran, "Dongchong Xiacao Yu Maoyan," *Guoxun* 156 (1937): 100; Tao Bingzhen, *Kunchong Manhua* (Shanghai, 1937), 63–4; and Zhiren, "Dongchong Xiacao: Dongwu Hu, Zhiwu Hu," *Juequn Zhoubao* 3 (1946): 9.

The blend of scientific and indigenous knowledge about the caterpillar fungus also indicates the influence of local food or material culture on science communication.

The dissemination of exotic, scientific "truth" in modern China did not proceed smoothly. In the 1910s, several articles on the caterpillar fungus, published in, for example, *Tongsu Jiaoyu Bao* (Journal of popular education, Shanghai) and *Xinmin Bao* (Journal of new citizens, Shanghai), lack any scientific knowledge.[100] In 1924, the painter Zhu Fengzhu's article on *buke siyi* (the incredible) in a Shanghai magazine even actively promoted the transformation theory of the caterpillar fungus on the basis of his observation of this wonder from Sichuan. Zhu strongly asserted that the caterpillar fungus transcended the categories of animals and plants; and when compared with bats, another organism that crossed the boundaries of birds and beasts, the caterpillar fungus no longer seemed so implausible. To induce readers to accept his opinion, he confidently suggested readers buy samples from drugstores and examine them with their own eyes.[101] Zhu's view could claim to be verifiable through observation, because what would be seen largely depended on, according to Lorraine Daston and Peter Galison, "what it [the subjective self] hoped to see."[102] In particular, as an author lamented in *Shenbao* (Shanghai news) in the same year, the caterpillar fungus was still popularly considered among the Chinese to be a magical, transformable organism.[103] Furthermore, the scientific theory of its life cycle had not yet been directly confirmed by a continuous one year or longer field observation in cold alpine environments or laboratories, which also contributed to the survival of the transformation theory in Chinese society.

Scientific research on the caterpillar fungus in China appeared in the Republican period. This period featured the growth of scientific professionalization and institutionalization, as well as the rise of scientific nationalism against the background of creating a vigorous, united, and modern Chinese nation through science.[104] Deng Shuqun pioneered Chinese mycological research on this fungus. In 1932, Deng, then working at the Science Society of China in Nanjing, reported his identifications of some fungi in southeastern areas of China, among which were specimens of "Cordyceps sinensis (Berk.) Sacc." obtained from a drugstore in Sichuan in 1928.[105] Two years later, his identifications and descriptions of the caterpillar fungus and the other forty-one fungal species were published.[106] This time he gave more detailed descriptions of its geographical range and natural habitat, produced an illustration of its fruiting bodies, and added an account of the structural characteristics of its stromata,

[100] "Dongchong Xiacao," *Tongsu Jiaoyu Bao* 1 (1913): 1; Chai Zifang, "Dongchong Xiacao," *Xinmin Bao* 2 (1915): 33–4.

[101] Zhu Fengzhu, "Buke Siyi Zhi Chonglei," *Hong Zazhi* 2 (1924): 1–6.

[102] Daston and Galison, *Objectivity* (cit. n. 77), 34.

[103] Li, "Ji buchongcao," *Shenbao*, 4 April 1924, section 8.

[104] Zuoyue Wang, "Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China," *Osiris* 17 (2002): 291–322.

[105] Shu Chun Teng, "Additional Fungi from Southwestern China," *Contributions from the Biological Laboratory of the Science Society of China: Botanical Series* 8 (1932): 1–4; Di Lu, "Recording Fungal Diversity in Republican China: Deng Shuqun's Research in the 1930s," *Archives of Natural History* 46 (2019): 139–52.

[106] Shu Chun Teng, "Notes on Hypocreales from China," *Sinensia* 4 (1934): 269–98. Deng's description of the caterpillar fungus in this article was later assimilated into his 1939 mycological monograph; see Shu, *A Contribution to Our Knowledge of the Higher Fungi of China* (n.p.: National Institute of Zoology & Botany, Academia Sinica, 1939), 41.

perithecia, and spores. Deng's publications laid a partial foundation for Pei Jian's 1947 article introducing up-to-date scientific knowledge of the caterpillar fungus and snow fungus, both of which the Chinese then alleged to be tonics suitable for everyone. Pei's article reveals scientific attention to local food or material culture. A research fellow of the Institute of Botany, Academia Sinica, Pei provided an illustration of new specimens of the caterpillar fungus, which, in contrast with Deng's, additionally showed anatomical and microscopic structures such as the transverse section and asci.[107] Both Deng and Pei's illustrations included scale bars, adding to the unprecedented accuracy in morphological representation of the caterpillar fungus in China.

The caterpillar fungus also incited related chemical or pharmaceutical research. In the 1940s, Tang Tenghan and his collaborators at the West China Union University (Chengdu) reported their analysis of chemical constituents in the caterpillar fungus, which might assist further exploration of bioactive constituents.[108] Also in Chengdu, Yang Shoushen, principal of the Military Academy of Veterinary Medicine, published his preliminary study of "Cordycepin," a fat-soluble crystal extracted by chemical methods from specimens of the caterpillar fungus growing in Lijiang. Beyond toxicity testing of Cordycepin in animals, he also carried out in vitro experiments to determine its antibacterial properties, because he hypothesized that *Cordyceps sinensis* must generate some substance that inhibited the growth of rival microorganisms in the larvae. He expected this study to contribute to research on issues relating to bacterial infections in animals.[109] These institutionalized studies did not interact with native culinary or medical knowledge about the caterpillar fungus, but were devised and performed in scientific contexts. They also demonstrated no disapproval of the medical, tonic, or culinary value of the caterpillar fungus. Some later historians even felt discontented with the neglect of native medical knowledge, valuable for scientific inquiry, in such chemical or pharmacological research on local medicinal substances in the Republican period.[110] Compared with microscopic observations, such research delved deeper into the interior of the caterpillar fungus, and thereby created new boundaries of knowledge beyond the reach of traditional empirical knowledge.

The localization of modern science in China was characterized in part by the combination of scientific practice and local natural products. In his 1909 research article on a Chinese fungus, Wang Huanwen, then studying pharmacology in Japan, wrote that the Japanese pharmacologist Nagai Nagayoshi once told him it was reasonable for native people to perform (scientific) research on domestic natural products.[111] Nearly forty years later, the principal of the National Specialist School of Materia Medica (Nanjing) formulated four missions for the school, the first of which was aimed at special Chinese medicinal substances and their effective constituents.[112] As

[107] Pei Jian, "Yiner He Xiacao Dongchong," *Kexue Shijie* 16 (1947): 102–4.

[108] Tang Tenghan, Wang Zhaowu, and Chen Xuhuang, "Dongchong Xiacao (Chongcao) Zhi Chubu Yanjiu," *Zhongguo Yaoxuehui Huizhi* 3 (1945): 1–4.

[109] Yang Shoushen, "Dongchong Xiacao Junsu (Cordycepin) Zhi Chubu Yanjiu Baogao," *Guofang Kexue Jianbao* 2 (1948): 711–17.

[110] Chen Xinqian and Zhang Tianlu, *Zhongguo Jindai Yaoxueshi* (Beijing: Renmin Weisheng Chubanshe, 1992), 216–17.

[111] Wang Huanwen, "Bukuryō No Seibun Ni Ju Te" (cit. n. 22), 472.

[112] Meng Xinru, "Yaowu Kexue Zhi Guoqu Ji Guoli Yaoxue Zhuanke Xuexiao Zhi Shiming," *Yaoxun Qikan* 5 (1947): 1–4.

indigenous material culture often sparked scientific attention toward local food, remedies, tonics, and economic plants, state-aided modern science promoted the reconstruction of knowledge about the caterpillar fungus and many other natural objects. In the Chinese physician Chen Cunren's 1935 dictionary of Chinese materia medica, which was intended to stimulate scientific research on native medicinal substances, the entry for the caterpillar fungus presented itself as an integration of some modern biological knowledge (from Chinese and Japanese sources) and vernacular knowledge about the plant's ancient names, production areas, appearance, medicinal properties, medical applications, culinary preparations, and so forth.[113] The popularity of Chen's dictionary helped spread a new eclectic intellectual face of the caterpillar fungus in society.[114] Similar to the entry, some other Republican records dedicated to a scientific caterpillar fungus also demonstrated that modern science would not necessarily drive out vernacular culinary or medical knowledge.[115] Even in Britain, the news reporting James W. Spreckley's "three bundles of the Chinese fungus, *Cordyceps sinensis*" presented to the Department of Botany of the British Museum, and published in the scientific journal *Nature* in 1930, still informs that it was a "celebrated drug" and was "said to bestow energy and to be partaken of with stewed duck."[116]

CONCLUSION

Anna L. Tsing's anthropological study of the delectable matsutake mushrooms as examples of "interspecies entanglements" indicates the intersections between "science and vernacular knowledge" and "international and local expertise."[117] The caterpillar fungus counts as an interspecies complex that, however, embodies parasitism rather than the mutualism represented by matsutake and pine trees. It is a complex that crosses boundaries of species through time, but explanations of its formation varied in different periods and cultures. It also crosses boundaries of identity. In Republican China, the caterpillar fungus appeared in the tonic food produced and sold by some restaurants and food companies. It was a natural plant in its geographic range, and also an expensive commodity in the hands of merchants. Some physicians used it as a traditional medicinal substance; some scientists treated it as an object of scientific investigation; and some officials related it to national economic interests in a political and nationalistic context. Moreover, some conservative intellectuals, consumers, or practitioners of Chinese medicine believed in its ability to transform from a blade of grass to a worm; at the same time, some proponents of natural history and fungal

[113] Chen, *Zhongguo Yaoxue Dacidian* (cit. n. 11), 303–6.

[114] The entry of the caterpillar fungus in the dictionary had also been extracted and published separately in periodicals; see, for example, Chengren, "Dongchong Xiacao," *Xiandai Yiyao Zazhi* 1 (1945): 15–18. For the popularity of Chen's dictionary, see Shu Shan, "'Chongcao' Ji Qita: Lüetan Xichui De Miaoyao," *Tanfeng* 11 (1937): 511–13; and Chen, *Yinyuan Shidai Shenghuo Shi* (1973; repr., Shanghai: Shanghai Renmin Chubanshe, 2000), 262–5.

[115] See, for examples, Zhang Lu, "Dongchong Xiacao Zhi Yanjiu," *Kunming Jiaoyu Yuekan* 3 (1919): 1–2; Xu Ke, *Kangju Biji Huihan* (1933; repr., Taiyuan: Shanxi Guji Chubanshe, 1997), 324; Sun Zulie, "Tanpian: Dongchong Xiacao," *Minsheng Yiyao* 62 (1941): 26; Zhujun, "Yanxia Hua Chongcao," *Nong Zhi You* 10 (1947): 16–17; and Zong Zhen, "Dongchong Xiacao," *Kexue Shidai* 3 (1948): 37.

[116] "News and Views," *Nature* 126 (1930): 856; cf. "News: The Department of Botany of the British Museum," *North-China Daily News*, 22 December 1930, section 7.

[117] Anna L. Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton, N.J.: Princeton Univ. Press, 2015), vii, 287.

microscopy criticized traditional accounts of its natural properties and formation. In some cases, the two categories of audiences possessed different interests and aims, which did not simply set boundaries of knowledge about food, but also shaped somewhat incommensurable intellectual worlds. An essentialist view of this incommensurable categorization is nonetheless not always advisable, as many Republican actors, like Chen Cunren, actively engaged in the integration of scientific and local knowledge.[118]

According to Hiromi Mizuno, Imperial Japan (1868–1945) aspired "to be recognized by the West as a modern, civilized nation, as the Western powers were, and to celebrate the nation's particularity to build a national identity"; and modern science was linked with imperial mythology, "the absolute core of its national identity."[119] Tong Lam also states that since the beginning of the twentieth century, Chinese cultural and political elites have shared a myth that "modernity is purely rational and that the triumph of science and reason is a self-evident, natural, and unproblematic process."[120] The powerful rhetoric of modern science embodied in the shaping of the truthfulness of the caterpillar fungus in China was initially imported from Japan through translation at the beginning of the twentieth century. With the dissemination of scientific knowledge and the caterpillar fungus in Japan, significant changes in Japanese perceptions of the fungus emerged and persisted throughout the nineteenth century. This natural curiosity was incorporated into the category of insect-fungi, which crossed the boundary between the caterpillar fungus and other similar insect-fungi; it was also deconstructed into two different and untransformable species grouped with other similar species in the European natural order; microscopic structures were invoked in support of the scientific theory of its formation; and interestingly, the Chinese term for it also entered the Japanese language, with its meaning being broadened to encompass other similar insect-fungi, indicating the semantic boundaries of shared vocabulary. As this new scholarship prevailed in Republican China, the caterpillar fungus would sometimes transform into a scientific wonder that prompted new facts within different scientific boundaries. However, modern science did not dispel indigenous culinary, medical, or other forms of empirical knowledge about the caterpillar fungus. This case study of the fungus and related boundary issues reveals both rupture and continuity in knowledge about food in Republican China's pursuit of science as modernity.

[118] Volker Scheid, *Currents of Tradition in Chinese Medicine, 1626–2006* (Seattle: Eastland, 2007), 202–8; Bridie Andrews, *The Making of Modern Chinese Medicine, 1850–1960* (Vancouver: Univ. of British Columbia Press, 2014), 112–205; Erik J. Hammerstrom, *The Science of Chinese Buddhism: Early Twentieth-Century Engagements* (New York, N.Y.: Columbia Univ. Press, 2015); Jia-Chen Fu, *The Other Milk: Reinventing Soy in Republican China* (Seattle: Univ. of Washington Press, 2018), 109–28.

[119] Hiromi Mizuno, *Science for the Empire: Scientific Nationalism in Modern Japan* (Stanford, Calif.: Stanford Univ. Press, 2009), 2.

[120] Tong Lam, *A Passion for Facts: Social Surveys and the Construction of the Chinese Nation-State, 1900–1949* (Berkeley and Los Angeles: Univ. of California Press, 2011), 8.