The geographical distribution of grey wolves (Canis lupus) in China: a systematic review

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ABSTRACT

The grey wolf (Canis lupus) is one of the most widely distributed terrestrial mammals, and its distribution and ecology in Europe and North America are largely well described. However, the distribution of grey wolves in southern China is still highly controversial. Several well-known western literatures stated that there were no grey wolves in southern China, while the presence of grey wolves across China has been indicated in A Guide to the Mammals of China, published by Princeton University Press. It is essential to solve this discrepancy since dogs may have originated from grey wolves in southern China. Therefore, we systematically investigated Chinese literatures about wild animal surveys and identified more than 100 articles and books that included information of the distribution of grey wolves in China. We also surveyed the collections of three Chinese natural museums and found 26 grey wolf skins specimens collected across China. Moreover, we investigated the fossil records in China and identified 25 archaeological sites with wolf remains including south China. In conclusion, with the comprehensive summary of Chinese literatures, museum specimens and fossil records, we demonstrate that grey wolves do distribute across all parts of the Chinese mainland, including the most southern parts.

Keywords: China; Grey wolf; Distribution; Conservation

INTRODUCTION

The grey wolf, Canis lupus, is one of the most widely distributed terrestrial mammals (Young & Goldman, 1944). Grey wolves live in a wide variety of habitats, including the dry Arabian desert, the xeric Mediterranean shrublands, the coniferous forests of Siberia, and the frozen tundra on Ellesmere island (Mech, 1981). Despite extirpation from many parts of their previous range over the last few hundred years, by persecution from humans and habitat fragmentation (Hunter & Barrett, 2011; Young & Goldman, 1944), wolves still retain most of their original distributions.

The distribution and ecology of grey wolves are largely well described in Europe and North America. However, in more peripheral and remote parts of their distributions, detailed information is often lacking. In the western literature, the wolf has generally been reported to be distributed throughout the northern hemisphere, from N15° latitude in North America and N12° latitude in India to beyond the Arctic Circle, but has been considered to be absent from Africa and the southern East Asia (Mech, 1981). However, recent articles reported that the Egyptian jackal (Canis aureus lupaster, Hemprich and Ehrenberg 1833) was not a subspecies of the golden jackal (Canis aureus, Linneaus 1758) and should be reclassified as the African wolf, Canis lupus lupaster (Gaubert et al., 2012; Koepfli et al., 2015; Rueness et al., 2001). Similarly, the literature about wolves in China is limited outside China. This has led to misconceptions in the western literature about the distributions of wolves in
China. Four studies, all conducted by western researchers, stated that wolf has never been presented in large parts of China (Callaway, 2013; Larson & Fuller, 2014; Nowak, 2003; Sokolov & Rossolimo, 1985).

However, as will be shown in this study the grey wolf has a historical and current range across nearly the entire country of China. There are more than 100 Chinese articles and books involving investigations of wolves in China since the 1950s (Table 1), showing the distributions in detail. Most of these articles are species investigations at a provincial or local level, however, there is no comprehensive description of the current distribution of wolves across China. Therefore, we here summarized the Chinese literature concerning past and present distributions of wolves in China, in order to synthesize data from this rich source of regional investigations into a comprehensive map of wolf distribution in China, and to make this significant information available to an international audience.

Table 1 Literature list of distributions of wolves in China

| Province       | Investigation Year | Location                          | Reference         |
|----------------|-------------------|-----------------------------------|-------------------|
| Heilongjiang   | 2008-2009         | Eastern forests of Wandashan Mountains | Shen et al., 2011 |
|                | 1994-2001         | Sanjiang National Reserve         | Zhang et al., 2001|
|                | 1997-1999         | Tangwanghe river forest district  | He et al., 2003  |
|                | 1993-1995         | Grand Khiingan                    | Zhang et al., 1996a|
|                | 1988-1989, 1993-1995 | Northern Grand Khiingan          | Li et al., 1996  |
|                | 1984, 1987-1990, 1992 | Xingkai Lake Nature Reserve      | Li et al., 1993  |
|                | 1971-1980, 1981-1990 | Heilongjiang province            | Zhang et al., 1998b|
|                | N/A               | Heilongjiang province             | Zhang & Yu, 2005 |
|                | N/A               | Western Heilongjiang province     | Gao et al., 1999 |
| Jilin           | 1992-1993         | Yanbian                           | Qiu et al., 1995 |
|                | 1992-1993         | Junjiang                          | Li et al., 1994  |
| Liaoning        | 1999-2002         | Nuluerhusan National Reserve      | Zhou et al., 2007|
|                | 1996-2000         | Benxi                             | Zhao et al., 2004a|
|                | 1996-2000         | 37 counties in Liaoning province  | Zhao et al., 2004b|
|                | 1996-1999         | Fushun                            | Zhao et al., 2001|
|                | N/A               | Yiwulv Mountain National Nature Reserve | Liu et al., 2008 |
|                | N/A               | Liaoayang                         | Wang et al., 2004|
| Inner Mongolia  | 1985-1986         | Jufeng Shan                       | Liu & Liu, 1999  |
|                | N/A               | Chaiehe                           | Xiao et al., 2013|
|                | N/A               | Hulunbair & Hinggan               | Gao et al., 1999 |
| Beijing        | 1982-1983         | Changping & Miyun                 | Zhang, 1984      |
|                | N/A               | Beijing                           | Wu et al., 2006  |
| Tianjin        | N/A               | Tianjin                           | Wu et al., 2006  |
| Shanxi          | 2010-2011         | Pangquangou National Nature Reserve | Wang & Zhao, 2011|
|                | 1996-1997         | Luyashan Nature Reserve           | Qiu et al., 1998 |
|                | N/A               | Northeastern Loess Plateau        | Chen, 2000       |
| Hebei           | 1993-2001         | Chengde                           | Hou et al., 2004 |
|                | N/A               | Hebei province                    | Wu et al., 2006  |
|                | N/A               | Saihanba                          | Hou et al., 1994 |
| Gansu           | 2007-2009         | Sunan and Subei prairie           | Zhao et al., 2011|
|                | N/A               | Gannan plateau                    | Chen & Li, 1994 |
|                | N/A               | Longnan mountain                  | Chen et al., 1994|
|                | N/A               | Tianshui                          | Hu et al., 1993  |
|                | N/A               | Minqin desert                     | Chen, 1992       |
|                | N/A               | Anxi                              | Chen & Luo, 1991 |
| Province | Investigation Year | Location | Reference |
|----------|--------------------|----------|-----------|
| Xinjiang | 1994-1996          | Kanas National Nature Reserve | Abdukadi et al., 1999 |
|          | 1987-1988          | Wuqia, Taxkorgan, Yecheng, Qiemo, Yutian | Feng, 1990 |
|          | 1965, 1980, 1983, 1985 | Zhungeer & Altai | Zhang & Hu, 1988 |
|          | 1979               | Xinjiang | Gao, 1997b |
|          | 1958-1961          | Desert plains area in Xinjiang | Zhang, 1963 |
| N/A      |                    | West Tianshan National Nature Reserve | Liu et al., 2007a |
| Ningxia  | 2010-2011          | Luoshan National Nature Reserve | Qin & Chang, 2012 |
| Shaanxi  | 2006               | Huanglongshan National Reserve | Li & Liu, 2009 |
|          | 2006               | Micangshan Nature Reserve | Wen et al., 2008 |
|          | 1997-2000          | Changqing National Nature Reserve | He, 2001 |
|          | 1999               | Zhashui | Hu et al., 2003 |
|          | 1996               | Zhouzhi National Nature Reserve | Li & He, 1997 |
|          | 1963-1966          | Ankang | Wu & Li, 1982 |
|          | 1959               | Daba mountain | Wang et al., 1981 |
| N/A      |                    | Shaanxi province | Li et al., 2006 |
| Qinghai  | 2001-2002          | Qilian mountain | Xia et al., 2003 |
| N/A      |                    | Beichuan River Nature Reserve | Zhang & Pu, 2012 |
| N/A      |                    | Qinghai lake area | Kong et al., 2011 |
| Tibet    | 2001-2002          | Upper Zayu river basin | Wu, 2006 |
|          | 1987-1988          | Ngari & Naqu | Feng, 1990 |
| Sichuan  | 2006               | Kasha Lake National Reserve | Li et al., 2013 |
|          | 1997, 2006         | Ruoergai Wetland National Reserve | Liu et al., 2009 |
|          | 2005-2006          | Maozhai Nature Reserve | Liu et al., 2007b |
|          | 2003-2005          | Haizishan Nature Reserve | Liu et al., 2007c |
|          | 2004               | Heizhugou Nature Reserve | Liu et al., 2005a |
|          | 2002-2003          | Jiuzhaigou National Nature Reserve | Liu et al., 2005b |
|          | 2002-2003          | Daofengding Nature Reserve | Liu et al., 2004 |
|          | 2002-2003          | Yele Nature Reserve | Zhang & Hu, 2004 |
|          | 2001-2002          | Huanglong Nature Reserve | Zhu et al., 2010 |
|          | 2002               | Xuebaoding Nature Reserve | Sun et al., 2006 |
|          | 2001               | Pingwu | He et al., 2004 |
|          | 1998               | Big-small Langou Nature Reserve | Lu & Hu, 2003 |
|          | 1996               | Huanglongsi Nature Reserve | Hu et al., 2001 |
| N/A      |                    | Ganzi and Liangshan | Zhang et al., 2009 |
| N/A      |                    | Ruoergai Wetland National Reserve | Hao et al., 2008 |
| N/A      |                    | Wolong Nature Reserve | Yu et al., 1983 |
| Yunnan   | 2010-2011          | Lanping Yunling Provincial Nature Reserve | Cui et al., 2014 |
|          | 2010-2011          | Weiixi | Zha et al., 2014 |
| N/A      |                    | Yunnan province | Yang et al., 1999 |
| Guizhou  | 2005-2006          | Leigong Mountain National Nature Reserve | Chen et al., 2008 |
| N/A      |                    | Guizhou province | Luo & Li, 2001 |
| N/A      |                    | Weining | Huang, 1989 |
It is controversial to describe the distribution of grey wolves in western literatures. Two articles reported that wolves were previously present all across China, but is now extinct from southern China (Ginsberg & Macdonald, 1990; Lau et al., 2010). In four well-known studies, researchers claimed that wolves have never existed in southern China (Callaway, 2013; Larson & Fuller, 2014; Nowak, 2003; Sokolov & Rossolimo, 1985), suggesting that southern China cannot be the harbor of dog domestication. Thus, southern China is usually treated outside the range of wolf distribution (IUCN; EOL). However, in 2008, Smith and his colleagues described the distribution of wolf in China, indicating that grey wolves were present all across the mainland of China (Smith & Xie, 2008).
Yanqi, Korla, Aksu, Luntai, and Baicheng of Xinjiang, In Shanxi province, in Yan’an of Shaanxi, in Mianchi and Luoning of Henan, in Yichang of Hubei, in Nanjing and Qingjiang of Jiangsu, in Fujian province, in Longzhou, Ningming, and Shangsi of Guangxi, in Guangdong province, in Guizhou province, in Lushui and Chengkou of Yunnan, in Yumen, Zhangye, and Linxia of Gansu, in Menyuan, Qilian, Alaer, Golmud, and Delingha of Qinghai, in Pali, Nylamu, Tingri, Shigatse, and Naqu of Tibet, and in Shiqu, Ruqergai, Songpan, Leibo, Ebian, Kangding, Wanxian, Yibin, and Mianyang of Sichuan” (Gao & Wang, 1987).

Furthermore, Wang (2003) described the subspecies/subtypes of grey wolves in China and reported that they were distributed across all parts of continental China. Chinese wolves were divided into five subspecies and forms: *Canis lupus desertorum* Bogdanow, 1882 in Xinjiang, *C. l. filchneri* Matschie, 1907 in Qinghai, Gansu and Tibet, *C. l. chanco* Gray, 1863 in Heilongjiang, Jilin, Liaoning, Inner Mongolia (eastern part), Hebei, Beijing, Shandong, Henan and Shanxi, *C. l. Nei-Mongol* form in Inner Mongolia (western and mid part) and *C. l. South-China* form in Anhui, Jiangsu, Zhejiang, Jiangxi, Fujian, Guangdong, Hunan, Guizhou, Yunnan, Hubei and Sichuan.

In order to obtain an updated and comprehensive description of the distribution of wolves in China, we investigated more than 100 articles containing information about the presence of wolf at a regional level (see a full list of literature in Table 1). The most recent evidence of wolf in each province (Figure 1) were extracted from the following papers: Heilongjiang (Shen et al., 2011), Jilin (Qiu et al., 1995), Liaoning (Zhou et al., 2007), Inner Mongolia (Li & Liu, 1999), Beijing (Zhang, 1984), Tianjin (Wu et al., 2006), Shandong (Wang & Zhao, 2011), Hebei (Hou et al., 2004), Gansu (Zhao et al., 2011), Xinjiang (Abdukadir et al., 1999), Ningxia (Qi & Chang, 2012), Shaanxi (Li & Liu, 2009), Qinghai (Xia et al., 2003), Tibet (Wu, 2006), Sichuan (Liu et al., 2013), Yunnan (Cui et al., 2014), Guizhou (Chen et al., 2008), Chongqing (Han et al., 2010), Henan (Gan & Fan, 2004), Hubei (Wang et al., 2007), Hunan (Fu, 1987), Jiangxi (Wu et al., 2012), Shandong (Sun, 1988), Anhui (Wang et al., 1966), Jiangsu (Wang & Zhao, 2008), Zhejiang (Ding et al., 2008), Fujian (Chen et al., 2009), Guangxi (Xia et al., 2002), Guangdong (Fellowes et al., 2003).

![Figure 1 Distributions of wolves in China](image)
The latest investigation year recorded in literature in 26 provinces (in red) and the latest publication year of literature in three provinces (in green) are indicated within brackets.
In summary, these investigations showed that the wolf has been recorded in every continental Chinese province between 1964 and the present, except in three provinces (Figure 1 in green). Most notably, wolves were recorded in South China (in Yunnan province) as late as 2011 and in the two southernmost continental provinces (Guangdong and Guangxi) in the year of 2000. From these findings we concluded that wolves are still present across all parts of continental China.

WOLF SKINS IN ZOOLOGICAL MUSEUMS

In addition to the literature investigation, we made a survey of wolf skins in the archives of the National Zoological Museum of China, Kunming Natural History Museum of Zoology, and Shaanxi Institute of Zoology, and (Table 2, Figure 2, Figure 3).

Table 2  Sources and geographical origins of wolf skin specimens

| Museum                                | ID | Province          | Location          | Date       |
|---------------------------------------|----|-------------------|-------------------|------------|
| The National Zoological Museum of China, Beijing | 1  | Heilongjiang      | Baoqing           | N/A        |
|                                       | 2  | Heilongjiang      | Baoqing           | 1957.01.24 |
|                                       | 3  | Inner Mongolia    | Xiguitu (Yakeshi) | 1954.12.10 |
|                                       | 4  | Jilin             | Baicheng          | 1957.02.11 |
|                                       | 5  | Jilin             | Jingyu            | 1956.03.08 |
|                                       | 6  | Jilin             | Kaitong           | 1956.06.13 |
|                                       | 7  | Xinjiang          | Buerjin           | 1974       |
|                                       | 8  | Xinjiang          | Bole              | 1972.05.18 |
|                                       | 9  | Tibet             | N/A               | N/A        |
|                                       | 10 | Tibet             | Changdu           | 1976.1     |
|                                       | 11 | Tibet             | N/A               | N/A        |
|                                       | 12 | Beijing           | Yangqing          | 1984.04.28 |
|                                       | 13 | Sichuan           | Ruo’ergai         | 1961.07.03 |
|                                       | 14 | Yunnan            | Lushui            | 1960       |
|                                       | 15 | Fujian            | N/A               | 1974.05    |
|                                       | 16 | Zhejiang          | Lin’an            | 1974       |
|                                       | 17 | Yunnan            | Kunming           | 1967       |
|                                       | 18 | Yunnan            | Kunming           | 1957       |
|                                       | 19 | Yunnan            | Zhaotong          | N/A        |
| Kunming Natural History Museum of Zoology, Kunming | 20 | Yunnan            | Honghe            | 1985       |
|                                       | 21 | Guizhou           | N/A               | N/A        |
|                                       | 22 | Guizhou           | N/A               | N/A        |
|                                       | 23 | Jiangxi           | Zoo               | 1990.06.08 |
| Shaanxi Institute of Zoology, Northwest Institute of Endangered Zoological Species, Xi'an | 24 | Shaanxi           | Yan’an           | 1973       |
|                                       | 25 | Shaanxi           | Xunyang           | 1965       |
|                                       | 26 | Shaanxi           | Pingli            | 1965       |

DISCUSSION

In this study, we showed that contrary to what is reported in many references in the western literature, the grey wolf actually is present across virtually all parts of the mainland China. This correction is important in studies of wolf ecology and conservation. It gives a correct picture of the worldwide
The wolf has endured massive decline in population size and geographic range around the world during the previous two centuries, because of human influence including habitat loss, persecution, hunting (for obtaining, e.g., trophies, furs and material for traditional medicine), and depletion of prey (Beschta & Ripple, 2010; Callan et al., 2013; Levi & Wilmers, 2012; Ripple et al., 2014). Also in China, the distribution areas of wolves have severely decreased due to human mediated habitat loss and hunting (Gao, 1997a, 2006; Zhang, 1999). Official investigations from the middle of the 20th century reported that wolves were distributed in every province of China except some islands, but gave no exact numbers. Today, large populations remain only in the northwestern and northeastern parts of the country, Inner Mongolia and Tibet, but even in these regions, the numbers are relatively small, e.g., only 2 000 wolves in Inner Mongolia were reported in the 1990s (Gao, 1997a). We have here shown that wolves still seem to be present across all parts of the Chinese mainland, including the most southern provinces. Thus, even though habitat loss has been severe in urban and agricultural regions, wolves seem to have persisted in intervening regions.

The data about wolf distributions that we here present were investigations on either provincial or local level, whereas, a comprehensive ecological survey of the wolves in China. It is therefore not clear how the wolf populations in the different parts of China are interrelated. For example, it is not clear whether wolves recorded in the southern provinces represent permanent populations, or a steady stream of individuals migrating from the northern provinces. However, it is notable
Figure 3  Three museum wolf skin specimens
Specimens originating from Yunnan Province (left, ID 18 in Table 2), Jiangxi Province (middle, ID 23 in Table 2) and Shaanxi Province (right, ID 24 in Table 2).

Table 3  Fossil records of gray wolves

| Province   | County         | Archaeological site | Time                           | Reference          |
|------------|----------------|---------------------|--------------------------------|--------------------|
| Shanxi and Hebei | Yanggao and Yangyuan | Xujiaoyao              | About 100 000 years ago        | Zhang et al., 2003  |
| Shaanxi    | Pucheng        | Nanwan and Beiwan   | Epistleocene                   | p315               |
| Henan      | Anyang         | Xiaonanhai          | 22 150-11 000 years ago        | p320               |
| Heilongjiang | Harbin        | Yanjiagang          | 22 370±300 years ago           | p357               |
| Shanxi and Hebei | Yanggao and Yangyuan | Xujiaoyao              | 125 000-104 000 years ago      | Lv, 2004           |
| Hebei      | Yangyuan       | Banjing             | 108 000-74 000 years ago       | p100               |
| Shanxi     | Yanggao        | Shenquansi          | 11 720±150 years ago           | p102               |
| Liaoning   | Hacheng        | Xiaogushan          | Epistleocene                   | p207               |
| Chongqing  | Fjiie           | Yufupu               | 7 560±110 years ago            | p355               |
| Heilongjiang | Mishan        | Xinkaili             | 7 500-6 500 years ago          | Yuan, 2015         |
| Qiachar    | Tengjiagang    | Bronze age           |                                 | p114               |
| Hallin     | Xilinhe        | Bohai Kingdom (698-926 A.D.) | p115                  |
| Jilin      | Nong’an        | Zuojiashan          | 6 800-4 800 years ago          | p115               |
| Liaoning   | Dalian         | Guojiacun            | 5 780-4 300 years ago          | p118               |
| Inner Mongolia | Linxi      | Baiyingchanghan     | 8 000-5 000 years ago          | P120               |
| Baotou     | Yanjiakang     | 1 275-3 727 years ago |                                 | p127               |
| Shaanxi    | Nanzheng       | Longgangsi          | 6 500-6 000 years ago          | p130               |
| Tongchuan  | Beicun         | Shang Dynasty (1 600-1 046 B.C.) | p133            |
| Hebei      | Xuishui        | Nanzhuangtou        | About 10 000 years ago         | p144               |
| Beijing    | Fangshan       | Zhenjiangying and Tazhao | Shang and Zhou Dynasties (1 600-256 B.C.) | p145          |
| Shandong   | Yanzhou        | Wangyin             | 6 500-5 500 years ago          | p147               |
| Weifang    | Qianbuxia      | Houli Culture (8 500-7 500 years ago) and 5 500-5 000 years ago | p147               |
| Tibet      | Naqu           | Chaxiutang          | 9th-11th century A.D.          | p155               |
| Hubei      | Zigui          | Liulinxi             | Neolithic age, Erlithe Culture (21st-15th century B.C.), and the Eastern Zhou Dynasty (770-256 B.C.) | p158               |
| Badong     | Lijiaotou      | Eastern Zhou Dynasty (770-256 B.C.) | p164           |
| Jiangxi    | Wannian        | Xianrendong         | About 12 000 years ago         | p166               |
that wolves have been recorded across virtually the entire continental China, including southern Chinese province Yunnan as late as in 2011 and provinces Guangdong and Guangzhou in 2000. These findings indicate a consistent presence of permanent populations across southern China. Moreover, to obtain a comprehensive picture of the status of the wolves in China, it is necessary to carry out both ecological and genetic studies, e.g., in concerning the genetic relationships among the wolf populations across China and between these and worldwide wolf populations.

This study points out misconceptions in the western literature about the distributions of wolves in China. The origin of this problem is not clear, but it can be traced back as far as an article in 1985 from which the factoid has, stepwise, been passed on to other articles (Sokolov & Rossolimo, 1985). It is probably because of the linguistic barrier to the Chinese literature that this error has previously not been pointed out. This case can be explained by inefficient research in peripheral parts of the species distribution, in countries with limited resources. Our study raises the question whether this kind of misconceptions also exist in other species than just the grey wolf.

CONCLUSIONS

With a comprehensive summary of Chinese literature, specimens and fossil records, we showed that wolves are present across all parts of the Chinese mainland, including the southern parts. Hereby we corrected an error in western literature, in which most sources stated that wolves were not present in the southern China, and some even claimed that wolves have never been presented there, even in ancient times. There is no comprehensive description of the current distributions of wolves across China, and therefore this study serves both to give an updated description of wolf distributions in China, and to make this significant information available to an international audience.

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