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The Strange Flight of the Peacock: Farmers' Atypical Northwesterly Migration from Central China, 200 BC–1400 AD

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A common Chinese proverb—"A peacock flies southeast"—could describe the normative idea of the southeasterly spread of agriculturalists as a trend in historical China. Indeed, northwest China was the least attractive place to agriculturalists because of its much harsher climatic conditions. Previous research on the historical northwesterly movements of Chinese farmers has relied on isolated case studies and suggested a variety of causes. This study is the first attempt to bridge geographical and historical methodologies considering the influences of climate change to supplement current ideas about Chinese migration. This study surveyed 195 individual cases of northwesterly migration of agriculturalists from central China and along the Silk Road Region from 200 BC to 1400 AD, comparing historical records of these migration cases to extensive paleoclimate data. We found statistical evidence that the northwesterly movements of farmers increased when the climate was drier. The historical records were consulted to explain this seemingly atypical pattern. We conclude that the agriculturalists' northwesterly migration increased during dry periods mainly as a response to the southward invasion of northern nomads, which was also a result of increased aridity. These conclusions add to the growing literature that indicates climate change as a central driver in intergroup conflict, having geopolitical implications. Forward-looking strategies relating to trade and immigration in the region, including the One Belt and One Road Initiative, should consider the shrinkage of rainfall under the potential threats of global warming. Increased aridity could have sizable effects on political, social, or economic structures far from north-central China. *Key Words: climate change, historical China, northwesterly migration of agriculturalists, One Belt and One Road Initiative, paleoclimate archive.*

"孔雀东南飞" 这个常见的中国谚语，能够描绘中国历史上的农民向东南方延伸的趋势之规范性概念。对农民而言，中国西北部因严苛的气候条件，的确是最不具吸引力之处。过往对于中国农民往西南方移动的研究，往往倚赖孤立的案例研究，并指出多种导因。本研究首次尝试结合考量气候变迁影响的地理学与历史学方法，以补充当前有关中国迁徙的概念。本研究调查西元前两百年至西元一千四百年间，中国中部沿着丝路地区往西北迁徙的一百九十五位农民的各别案例，并将这些迁徙案例的历史纪录与大规模的史前气候数据进行比较。我们发现当气候更乾燥时，农民往西北部迁徙增加的统计证据。我们诉诸历史证据来解释此一看似反常的模式。我们于结论中主张，乾旱时期农民往西北方迁徙的增加主要是反应北方游牧民族的向南侵略，而该行动本身亦由乾旱加剧所导致。这些结论对于指出气候变迁作为群体间的冲突之导因的增长中的文献做出贡献，并具有地缘政治意涵。该区域有关贸易和迁徙的前瞻策略，包含一带一路倡议，应该考量全球暖化的潜在威胁下降雨的减少。增加的乾旱可对中国中北部以外的政治、社会或经济结构带来巨大的影响。*关键词: 气候变迁，历史上的中国，农民的西北迁徙，一带一路倡议，史前气候档案。*

Un proverbio chino común—"Un pavo real vuela hacia el sudeste"—podría describir la idea normativa de la dispersión hacia el sudeste de los agricultores como una tendencia en la China histórica. En verdad, la China del noroeste fue el lugar menos atractivo para los agricultores debido a sus muy severas condiciones climáticas. La investigación anterior sobre los movimientos históricos hacia el noroeste de granjeros chinos ha dependido de estudios de casos aislados; allí se sugirió una variedad de causas. Este estudio es el primer intento de unir metodologías geográficas e históricas para considerar las influencias del cambio climático como suplemento de las ideas corrientes acerca de la migración china. El estudio exploró 195 casos individuales de migración de agricultores hacia el noroeste desde la parte central de China y a lo largo de la región de la Ruta de la Seda desde el 200 a.C. hasta 1400 d.C., comparando los registros históricos de estos

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casos de migración con datos paleoclimáticos extensos. Hallamos evidencia estadística de que estos movimientos de granjeros hacia el noroeste se incrementaron cuando el clima era más seco. Se consultaron los registros históricos para explicar este patrón aparentemente atípico. Concluimos que la migración de los agricultores hacia el noroeste se incrementó durante los períodos secos principalmente como respuesta a la invasión hacia el sur de nómadas norteños, movimiento que era también el resultado de creciente aridez. Estas conclusiones se suman a la creciente literatura que indica el cambio climático como un control central de conflictos entre grupos, con implicaciones geopolíticas. Las estrategias de avanzada relacionadas con comercio e inmigración en la región, incluyendo la Iniciativa de Un Cinturón y Una Ruta, deben considerar la reducción de la pluviosidad bajo las amenazas potenciales del calentamiento global. El incremento de la aridez podría tener efectos considerables sobre las estructuras políticas, sociales o económicas mucho más allá de la parte centro-norte de China. *Palabras clave: archivo de paleoclima, cambio climático, China histórica, Iniciativa de Un Cinturón y Una Ruta, migración de agricultores hacia el noroeste.*

The Chinese proverb "A peacock flies southeast"[1] not only suggests the preferred migration direction of talent and capital in the current era (Fu 2007) but also matches the main trend of agriculturalists' migration in ancient China (Pei, Zhang, and Lee 2016). Along with the progression of farming technology and introduction of high-yielding crop varieties in the past, the historical zone of sedentary agriculturalists generally expanded from the north toward the south of China (He, Li, and Liu 2010; Yin, Su, and Fang 2015). Settlers from this core agricultural area—called the *Zhongyuan* in Chinese—expanded across the Yangtze River as a result of a large number of migration events to east and south China (Ho 1956; Normile 1997; Barker 2012).

Despite considerable migration across all periods of historical China, scholars have commonly believed that Chinese farmers were generally reluctant to leave their ancestral homes (J. Lee 1978; Pei 2017; Pei, Lee, and Zhang 2018). If homebody farmers left, it had to be for a good reason; the principal reason would have been better, more fertile areas in which to farm. In general, precipitation and temperature increase as one moves from north China through the center toward the southeast. The Chinese peacock seeks moister and warmer nesting grounds, as the proverb suggests. Nonetheless—and heretofore seemingly atypically—there have been numerous extensive migrations of Chinese farmers toward the northwest. This pattern has attracted academic interest given that northwest China is not only a less climatically hospitable place for farming but also has long been regarded by farmers as uncivilized and deserted (Di Cosmo 2002). In Chinese history, the region known as Xinjiang and the western part of Inner Mongolia were mentally and culturally treated as barbaric "northwest China" (Fairbank and Goldman 2006) because northwestern nomads mainly lived in and came from this region (Bai and Kung 2011).[2] This mental and cultural northwest China is slightly different from the geographic northwest China that is at the center of the Eurasian continent (Shi et al. 2007). The northwest China in this study mainly refers to the mental and cultural northwest China, relative to the *Zhongyuan* core. Studies describing migration to the south or the east as the dominant trend have failed to explain variability in migration direction and the many northwesterly movements in Chinese history.

The atypical northwesterly migration from central China is the central research topic of this study. To be clear, more than three fifths to south as a main trend has been identified from the cases of agriculturalists' migration in central China of the past 2,000 years (Pei, Zhang, and Lee 2016). The impression of northwesterly migration as somehow atypical or counterintuitive is based on a generalized picture, rather than a careful evaluation of the narrative history of each case or any individual migrant. The events recorded in Chinese official history were usually written by government officials and royal historians who had limited access to details of events and contact with migrants. Heretofore, the single cases of migration have been compared to the general trend of southeasterly migration: Individual migrations toward the northwest have therefore seemed atypical.

Numerous studies have investigated northwesterly migration away from central China. Each of these explains a particular migration (or in any event a relatively limited number of migrations) with a particular explanation. Causation has been attributed to, for example, religion (Dillon 2004), commercial

activities along the Silk Road (Wood 2003), and territorial security (Waley-Cohen 1989). These perspectives are usually limited with the scope of social or political systems and describe a particular triggering event for each movement, rather than proposing a general theory for all such events. Previous studies have failed to see a "bigger" background variable—climate—as central, rather than peripheral. Our argument is that the climatic conditions could have potentially influenced farmers' migration in historical China (Pei, Lee, and Zhang 2018). Social conflicts within agricultural empires or wars of pastoralists and agriculturalists in historical China have recently been shown to be connected in a fundamental way with negative climate change when viewed on a longer term scale (D. D. Zhang et al. 2015; Carleton and Hsiang 2016).

Even though the association between climate change and agriculturalists' northwesterly migration has been explored in previous studies, the research methodologies employed previously have obvious limitations. First, although several studies have already used paleoclimate data to address issues of migration engendered by climate change, these studies look at migration over all of China (J. Q. Fang and Liu 1992; Pei, Lee, and Zhang 2018) on a large geographic scale. Studies on migration with special attention to a particular region like central China (Zhongyuan) are scarce. Dissimilar and even contradictory findings might be found depending on the spatial scale (Pei, Zhang, and Lee 2016). Although some studies such as that of Xiao et al. (2015) and X. Fang, Xiao, and Wei's (2013) study on north China exist, they have relatively short time spans, only covering recent history (Ming and Qing dynasties).

A second limitation is that these studies have merely investigated the occurrence of migration events, such as J. Q. Fang and Liu (1992) and H. F. Lee and Zhang (2010). Scholars working on this topic have heretofore not sufficiently investigated migration direction. This is considered one of the most pressing topics in migration studies (Yaukey 2007) and has not been sufficiently investigated, especially not in a rigorously quantitative manner. Geographic research on various continents such as North America, South America (deMenocal 2001), Europe, Africa, and Asia (Rouse 1986) suggests that migrations are not simply in all directions from an initial location but rather have a clear preference with regard to direction. Despite the importance of migration direction as an area of research, the seemingly atypical movement of Chinese farmers from the center toward the arid northwest in historical China has not been fully discussed in migration studies.

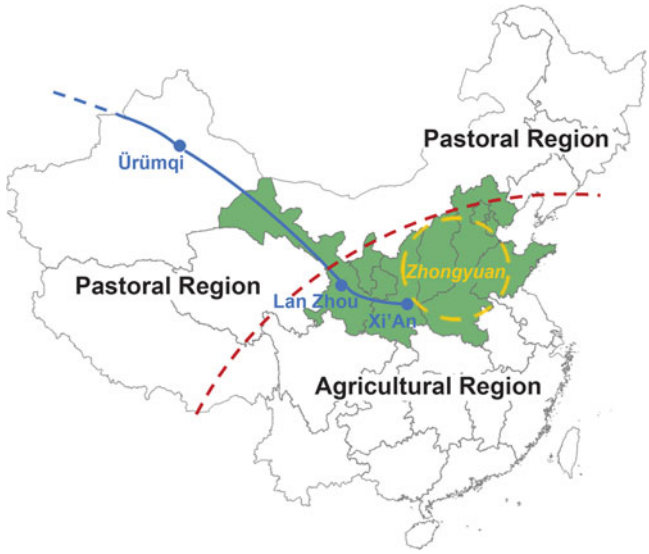

Figure 1. The study area (in green) of central China and the agrarian region along the Silk Road. The yellow circle indicates the core agricultural area, the *Zhongyuan*, in historical China. The blue line indicates the Silk Road in historical China. The red dashed line roughly indicates the divide of the pastoral region and agricultural region in historical China (Pei and Zhang 2014; D. D. Zhang et al. 2015; Pei, Zhang, and Lee 2016). (Color figure available online.)

Third, existing studies have used either geographic or historical methodologies, both of which—when used separately—have led to specific limitations in generalizability. Most historians work at a microscale based on historical records. Historians have considered impacts of climate change on a number of variables but not on the long-term tendency of farmers' migration. By contrast, large-scale geographic research has generally failed to take the historical records of these migrations seriously to present a complete image at the regional scale (Xiao, Fang, and Zhao 2018). For example, some scholars have transformed migration records into time series but then used these solely to check the association with the impacts of climate change (Pei, Zhang, and Lee 2016; Pei 2017). To improve the reliability of findings—and to generate a more broadly applicable explanation—the research presented here examined the historical records of all microscale migration events as well as the general pattern at the

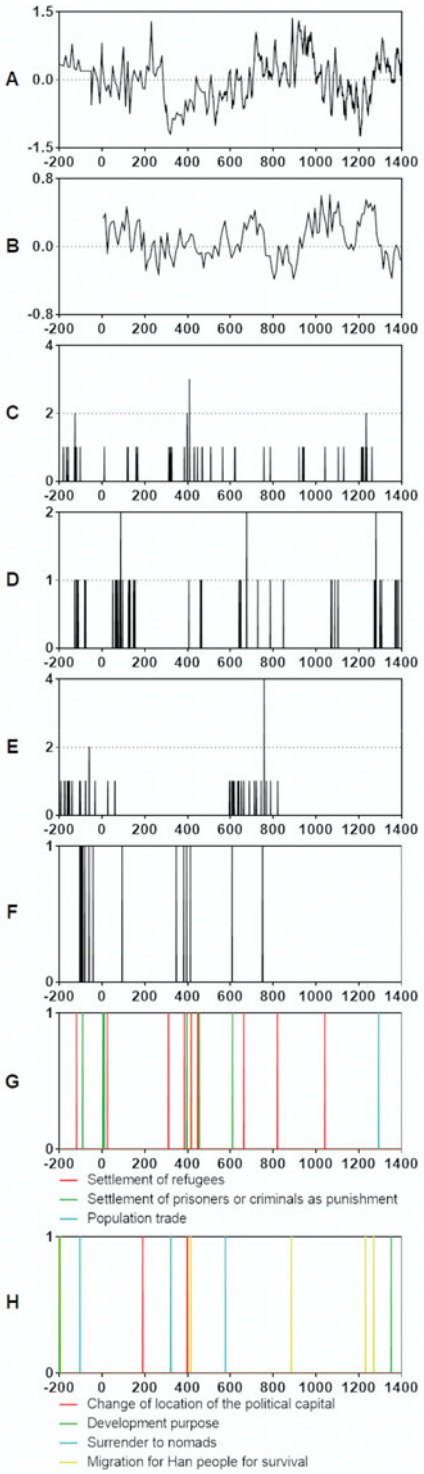

Figure 2. Climate conditions and records of each category (200 BC–AD 1400). (A) Precipitation anomaly (mm) from Pei et al. (2014). (B) Temperature anomaly (°C) from Ge et al. (2013). (C) Migration forced by northern nomadic minorities (number of incidents). (D) *Tuntian* (no. of incidents). (E) Allied marriage (number of incidents). (F) Agriculturalists' attack on northern nomadic minorities (number of incidents). (G)–(H) The rest of the migration types (number of incidents). (Color figure available online.)

macroscale by creating a long-term series of paleoclimate data. Quantitative analysis was combined with qualitative analysis on each detailed record to bridge the methodologies of geography and history.

As noted earlier, some explanations of northwesterly migration have connected it to the commercial activities along the Silk Road, an ancient network of trade routes and cultural interaction that started from the central Chinese city of Xi'an. Central China provided the resources, labor, and other necessary materials for trade along the Silk Road (Hansen 2015). The Silk Road was abandoned during the Ming Dynasty (1368–1644 AD; Whitfield, Whitfield, and Agnew 2015) and fell into disuse (Schlütter and Teiser 2012). Therefore, study of northwesterly migration not only could fill the current research gap but also has potential implications for the One Belt and One Road Initiative in contemporary China. This initiative seeks to create a modern Silk Road connecting China to central Asia and Europe.

In sum, this study focuses on central China and the agrarian region along the Silk Road as the study area shown in Figure 1. The study period is from 200 BC to 1400 AD, because China was still open for international communication until the early Ming Dynasty (1368–1644 AD; Broadberry et al. 2017). Records on the northwesterly migration of agriculturalists have been collated for both quantitative and qualitative investigation. The study findings are based on the combined evidence from the quantitative analysis of the paleoclimate data series compared to and contextualized with historical records of migration events. The study thus further aims to advance the knowledge on northwesterly migration with the supplementary perspective of climate change and quantitative analysis. Although limited in certain aspects, this broad-brush approach suits the study objectives of investigating, reviewing, and ultimately revising the current common knowledge about the northwesterly migration of agriculturalists away from central China on a long-term scale.

Data Sources

Paleoclimatic conditions and historical records on northwesterly migration are two key elements of this research for determining the credibility of the study. In terms of climate change, drought and cooling have been disastrous to human society in past eras

(Fagan 2000; Parker 2013). Precipitation and temperature are the two chief variables that determine climatic conditions (Gimmi et al. 2007). Therefore, this study uses precipitation and temperature to reflect paleoclimatic conditions. To guarantee data reliability, we based the precipitation (Figure 2A) and temperature (Figure 2B) series on the findings from data published in refereed journals. For the historical records, official histories of historical China including *Ershisi Shi*, *Zizhi Tongjian*, and *Siku Quanshu* were the main sources for textual references to migrations during the period of study.[3]

It is important to note that paleoclimate proxy sources reflect precipitation and temperature anomalies, not actual instrumental records. In paleoclimate studies, researchers reconstruct climate conditions based on different proxies, including documents, tree rings, lake sediments, and ice cores (Mann et al. 2008; Mann et al. 2009). Climate reconstruction is used only to reflect precipitation or temperature fluctuations, which can then be compared with instrumental records (PAGES-2k-Consortium 2013). Therefore, climate reconstruction is not a direct climatic record measured by current instruments, although reconstructed climate anomalies are scientific indicators of paleoclimatic conditions.

Precipitation

In China, the spatial and temporal abundance of historical records on weather events provides a good proxy network to reconstruct the variability of precipitation (D. E. Zhang 1998). Therefore, the study uses Pei et al.'s (2014) precipitation reconstruction (Figure 2A), which is based on historical documents of a total of twenty-one documentary-based single-proxy hydroclimate reconstructions (annual resolution) from thirteen published references (as shown in Table S.1 of the Supplementary Materials). There are unique merits of the comparison of documentary data with a paleoclimate record. Natural proxies used for precipitation reconstruction, such as tree rings and cave speleothems, usually also contain temperature signals (Dayem et al. 2010; Büntgen et al. 2011). Precipitation anomalies can be distinguished from the baseline in those natural proxies; when compared to sources in historical documents, they can provide a pure signal of precipitation in historical China (Brázdil et al. 2005; McCormick, Dutton, and Mayewski 2007). Historical (textual) sources not only provide a corroborating source for paleoclimate research but ultimately provide the qualitative explanation for the northwesterly movement of Chinese farmers.

To further guarantee the reliability of the selected precipitation series, this study selected the empirical orthogonal function (EOF) to reconstruct precipitation, adopting the aforementioned twenty-one data series. The EOF reconstruction is shown in the Supplementary Materials. Climate scientists have used the EOF method broadly to describe, reconstruct, and predict highly dimensional data fields. This function decomposes a space–time field into spatial patterns and associated time indexes, thereby considerably advancing the understanding of climatic systems (Hannachi, Jolliffe, and Stephenson 2007). The reconstructed EOF precipitation and reconstructed simple-average precipitation by Pei et al. (2014) are significantly and positively correlated (0.799, $p < 0.01$) to reflect the consistency between these two precipitation anomalies. Therefore, we base our analysis on Pei et al.'s (2014) precipitation reconstruction after the reliability test.

Temperature

This study adopted the temperature series reconstructed by Q. Ge et al. (2013) from multiproxies (including sediments, stalagmites, historical documents, tree rings, and ice cores) throughout China (Figure 2B). This series has a decadal resolution and spans the past 2,000 years. The temperature anomaly reconstructed by Q. Ge et al. (2013) is the most recent research on this subject and is considered one of the best sources for illustrating the relationship between climate change and social responses in historical China (Mauelshagen 2014). We recognize, however, that the length of reconstructed temperature by Q. Ge et al. (2013) does not cover the first 200 years of the study period.

Northwesterly Migration Records

The northwesterly migration series (Figures 2C–2H) was compiled according to the records shown in Table S.2 of the Supplementary Material. To merit inclusion in the series, migration events must first have been recorded in the *Ershisi Shi*, *Zizhi Tongjian*, or the *Siku Quanshu* and also have been present in the latest chronological table from *Zhong Guo Yi Min Shi*

(Chinese Migration History). This compilation was based in turn on the works of ancient Chinese royal historians and scientists from pastoralist and agriculturalist empires (J. Ge, Wu, and Cao 1997). Campbell, Lee, and Elliott (2002) and Campbell and Lee (2001) highlighted the value of Q. Ge et al.'s book for historical study of Chinese migration. This master collated and verified list became our northwesterly migration series. The *Zhong Guo Yi Min Shi* (Chinese Migration History) only has two cases of allied marriage. Given the possible importance of this kind of migration event, another thirty-eight cases of allied marriage were found from Cui's (2005) work, *Zhong Guo Gu Dai He Qin Shi* (Chinese History of Allied Marriage). This book has been widely adopted by academia as a standard work on the subject (Chin 2010; Dabringhaus 2011).

In China, each new Chinese dynasty compiled a history of its predecessor, using documents from the predecessor regime. These histories were perhaps partisan regarding the predecessor regimes, but present-day historians consider the three officially sponsored histories—*Ershisi Shi*, *Zizhi Tongjian*, and *Siku Quanshu*—more authoritative than other unofficial histories for understanding Chinese history in general, as well as for climate and migration specifically (Qiu 2004; Pei and Forêt 2018). This archival and historical practice was not based on personal records from the migrants themselves, however—by definition, they were moving away from the center (where court historians were) to the periphery. Due to historical silences imposed by Chinese archival practices, the study examines each case of migration on the micro-scale but then also attempts to classify the cases into larger categories. Rather than attempting to explain the particular, we compared historical records to climate data to determine possible general patterns. For each of the 195 northwesterly migration events noted in the historical sources consulted, we noted migration dates, departure places (or regions), and the intended destination places (or regions).

Methods and Results

This study used reconstructed paleoclimate data to quantitatively examine first the association with the northwesterly migration of Chinese farmers and, second, historical (textual) evidence to explain the statistical linkage of those two variables. We selected nonparametric correlation and multivariate Poisson regression analyses as the main statistical methods. Among different nonparametric methods, the Kendall correlation analysis is selected as a very commonly used one to robustly measure the strength of dependence between two variables (Huber and Ronchetti 2009). It works especially well when assumptions about normality and linearity do not hold (Kang and Sen 2008).

Table 1. Kendall rank correlation on precipitation, temperature, and northwesterly migration

	Precipitation	Temperature
Northwesterly migration	−0.057**	0.031
Significance (two-tailed)	0.009	0.154

Notes: **Coefficient is significant at the 0.01 level (two-tailed).

Table 2. Multivariate Poisson regression results on precipitation, temperature, and northwesterly migration

	Constant	Precipitation	Temperature
Coefficient	−2.369**	−0.510**	0.653
Significance (two-tailed)	< 0.001	0.003	0.099

Notes: The dependent variable is northwesterly migration.
**Coefficient is significant at the 0.01 level (two-tailed).

Data on the migration of agriculturalists from historical documents were recorded as count data. Thus, Poisson regression, which is the most suitable method for treating and validating count data, was specially adopted for analysis (Cameron and Trivedi 1998). Poisson regression is designed to use a logarithm model format (Brouhns, Denuit, and Vermunt 2002). Correlation analysis and multivariate linear regression results are listed in the Supplementary Materials to further verify the results of the two previously mentioned methods. We employed both nonparametric and parametric and nonlinear and linear statistical methods to scrutinize the association between climate change and agriculturalists' migration from 200 BC to 1400 AD. The statistical significance level was set at 0.05 (95 percent).

Macro Picture from Quantitative Analysis

The statistical results in Tables 1 and 2, which used precipitation data reconstructed by Pei et al. (2014), led to reciprocally consistent conclusions. Table 1 summarizes the nonparametric correlation analysis results to show that northwesterly migration is significantly and negatively correlated with precipitation but not significantly correlated with

temperature. This result means that long-term migration toward northwest China increased when precipitation decreased. Multivariate Poisson regressions were then conducted; the results are listed in Table 2 and are consistent with the results of nonparametric correlation analysis as well as the supplemental statistical results in the Supplementary Materials (Tables S. 4–S.6). All of these statistical results have the same implication: Long-term migration toward northwest China increased when precipitation decreased.

The bio-productivity of northern China is primarily controlled by precipitation (Sternberg 2008), whereas that of southern China is sustained by temperature (D. D. Zhang et al. 2007). Precipitation is thus of particular importance to the study area in north China. Northwesterly migration corresponds significantly with precipitation but not with temperature according to statistical results. Thus, precipitation—rather than temperature—seems to have been a more important variable for northwesterly migration in north China. Although the effect of temperature on migration remains limited during the study period according to Tables 1 and 2, this study recognizes the importance of temperature on a different spatial or temporal scale.

These statistical methods revealed that precipitation was significantly and negatively correlated with the northwesterly migration during our study period. Furthermore, the model based on our statistical findings predicted that northwesterly agriculturalists' migration would increase when precipitation lessens and drought occurs. Generally speaking, farmers would not move further northwest into an area of higher aridity, but they would be even more unlikely to do so in a moment in which there has been a general increase of aridity on the regional scale. This is perhaps the reason (in addition to insufficient data) why earlier studies have used a variety of other explanations for northwesterly migration of farmers. Northwesterly migration during periods of precipitation change shows a pattern that contradicts commonly accepted scholarly axioms, which hold that migration northwest should decrease under dry conditions. It is important to note that these are the axioms of scholars whose work is at the national rather than regional scale of historical China (Gong and Hameed 2007).

Water is one of the essential limiting natural factors in agricultural activities. Northwest China is quite dry relative to central and southeastern China. The quantitative analysis suggests what seems to be an irrational decision on the part of the farmers: They would be moving toward a drier area when they migrated toward the northwest. Thus, an analysis that is purely quantitative yields a seemingly strange conclusion. This study, however, is only implemented at a regional scale. If the spatial scale is narrowed down, then other social factors (like responses to nomads) should be considered and their influences might in that case be more important than climate change (Pei, Zhang, and Lee 2016). Therefore, historical records must be scrutinized in detail (particularly in relation to precipitation change) given the contradictions between statistical results and existing understandings of reasons for migration. The Chinese peacock might often fly southeast, but sometimes it flies to the northwest, into a storm.

Table 3. Comparison between the number of events during dry periods and in all periods

Category	Number of events during dry period	All events	%
(A) Migration forced by northern nomadic minorities	34	51	66.67
(B) *Tuntian* (defensive farming of soldier-farmers in the border region)	27	50	54.00
(C) Allied marriage	25	40	62.50
(D) Agriculturalists' attack on northern nomadic minorities	14	18	77.78
(E) Settlement of refugees	6	10	60.00
(F) Settlement of prisoners or criminals as punishment	8	9	88.89
(G) Population trade	1	1	100.00
(H) Change of location of the political capital	3	3	100.00
(I) Development purpose	2	2	100.00
(J) Surrender to nomads	1	3	33.33
(K) Migration of agriculturalists for survival	4	8	50.00

Categorization of Northwesterly Migration

On the basis of the documentary records shown in Table S.2 of the Supplementary Materials, we classified textual mentions of northwesterly migration into different categories, which we term *migration types*. The majority (159 of 195) of events fell into four migration types: (A) migration forced by northern nomadic minorities, (B) *Tuntian* (defensive farming of soldier-farmers in the border region), (C) allied marriage (marriage alliance), and (D) agriculturalists' attacks on northern nomadic minorities. Owing to the number of records on different types of northwesterly migration, only Types A, B, C, and D are further investigated. These four types constitute the majority of total selected records. Each of these four types potentially linked with social conflict is discussed with special attention in what follows. The rest of the migration types are as follows: (E) settlement of refugees, (F) settlement of prisoners or criminals as punishment, (G) population trade, (H) change of location of the political capital, (I) development purpose, (J) surrender to nomads, and (K) migration of agriculturalists for survival. Collectively, these seven migration types accounted for only 36 of the 195 migration events. Each data series of this classification is presented in Figure 2. Given the limited number of each migration type, statistical analysis was not performed.

Dry conditions must be interpreted scientifically as the basis and starting point of analysis to determine their negative impacts. To remain consistent with the negative coefficients of precipitation in the statistical analysis, decreasing levels of precipitation were associated with increased northwesterly migration. Therefore, both periods in which precipitation reached a nadir (bottom phase) and periods in which precipitation consistently declined from a zenith point were included. The other phases of the study period were tagged with improving or satisfactory precipitation conditions (wet periods).

Following this division of precipitation conditions, the number of events for each type was calculated during the dry period to compare with the general conditions shown in Table 3. We found that most northwesterly migrations occurred during dry periods, accounting for 64 percent of the total migration events.

Discussion

Valid statistical analysis usually requires a large spatial or long temporal scope with sufficiently abundant data to be able to derive what we have referred to elsewhere as a statistical law (Pei et al. 2014). The statistical results from such a large number of records from historical documents should be consistent with a general pattern derived from a majority of cases, although it might not be applicable to every specific case (Bunge 2009).

Our conclusions—derived from relatively abundant data to cover the whole of central China—should not have differed considerably from the leading patterns of findings from historical research based on detailed and exact records (Eijnatten, Pieters, and Verheul 2013). It is therefore surprising that our findings on northwesterly migration differ greatly from existing ideas about the general trend of agriculturalists' migration toward south China on a national scale (Pei, Zhang, and Lee 2016; Pei, Lee, and Zhang 2018).

As we narrow the scale and specify the target, factors apart from the climatic impacts—for example, particular local social and political factors—must be considered and perhaps given more explanatory weight than at a larger scale (Gibson, Ostrom, and Ahn 2000). At the limited scale of research like the case study level, textual and historical sources, rather than simply corroborating paleoclimate data, can be used to interpret and explain those data and illuminate human history (Chaplin 2015).

Figure 1 shows that the study region is in the ecologically transitional region between pastoral and agricultural China (D. D. Zhang et al. 2015). This special geographical feature has made the region the theater for many conflicts between farmers and nomadic minorities throughout Chinese history, particularly during the uncomfortable conditions of climate change (Bai and Kung 2011). According to past studies, nomadic minorities in the pastoral regions of China (as shown in Figure 1) migrated and invaded the south quite soon after climate change occurred (Pei and Zhang 2014; D. D. Zhang et al. 2015). Therefore, the reasons for northwesterly migration could go beyond climatic factors to include other social and political factors. Even though the results are significant in both Tables 1 and 2, the value of statistical analysis is quite low and must be treated conservatively. If the scale is narrowed down, the explanation from the perspective of climate change should be accorded a reduced weight relative to social or political factors (Aslanian et al. 2013). Explaining the northwesterly migration away from central China necessitates the consideration of different potential

factors, one of which is the impacts from adjacent regions where pastoralists resided. Such research will provide a holistic picture of historical migration in China based on a long-term scale analysis.

Chinese history cannot be isolated from the external influences of the nomads shown in Table S.2 of the Supplementary Materials. Although current research has complicated old binaries— "barbarians" versus agriculturalists, steppe versus sown—historically many cases have reflected invasions by nomadic minorities. These incursions interfered with agriculturalists' regimes in China. From 316 to 439 AD, five different nomadic minorities—namely, the Xiongnu, Xianbei, Jie, Qiang, and Zhi—invaded southward after the War of the Eight Princes of the Jin Dynasty. Historians normally refer to the subsequent war as the Uprising of the Five Barbarians. This resulted in several new regimes in north China. The Sui Dynasty reasserted control from the center in 589 AD. Beginning at the end of the Tang Dynasty in the eighth century and continuing to the tenth century, nomadic minorities were active again. When the Tang Dynasty collapsed, minorities took control of north China and set up several regimes, among them the so-called Later Tang, Later Jin, and Later Han. The first emperor of the Song Dynasty, Zhao Kuangyin, put an end to this Five Dynasties period. After the establishment of the Song Dynasty, northern nomadic minorities again slowly consolidated their military power. Threats from Qidan, Xixia, and Mongolia lasted throughout the Song Dynasty, from the tenth century to the thirteenth century. The Yuan Dynasty, a regime established by Mongolian pastoralists-turned-invaders, again reasserted the center's control of the northern periphery. Nomadic threats to central control in north China were present even during the Ming Dynasty.

The historical records surveyed here show the impacts of pastoralists on agriculturalists' migration. The four principal migration types—A, B, C, and D—of northwesterly migration of agriculturalists are all related to nomadic migration southward. For migration type A, nomadic minorities invaded the south and prompted Chinese dynasties to force farmers northwest, either as forced laborers or as enslaved people. These farmers were sent to pastoral regions as a buffer, to maintain or increase the available labor force, according to the historical records and other scholars' findings (Perdue 1998; Di Cosmo 2002). Therefore, the life of farmers in the study region was often threatened by potential invasion from nomadic minorities (Pei, Lee, and Zhang 2018). The Great Wall was constructed to keep nomads away from the agricultural region, although its effect is constantly debated (Scott 2009). Thus, we define migration type A as state directed rather than as voluntary; this type of migration was indirectly attributable to the military actions of a nomadic society confronting agriculturalists.

A closer examination of type B migration events reveals another kind of population redistribution by the agriculturalists' government to control the land along the border. The Chinese government sent troops to the border region; these were more than simple garrison troops, as they had a dual function as agricultural settlers. Given the generally low bio-efficiency of the land and the high cost of transport in imperial China (especially of bulky goods like grain), these border troops had to farm to meet their needs for food (Hartwell 1967). Therefore, farming and defense were conjoined in the *Tuntian* (military agricultural colony) system. *Tuntian* soldier-farmers had two goals: to administer the borders and to defend against external invasion from nomads; this system was regarded as one of the most effective means of achieving these goals (Sines 2002). Fifty-four percent of migration type B happened during dry conditions, which also suggests that agricultural defense by soldier-farmers was linked to nomadic invasions, triggered in turn by periods of high aridity, having a mirror meaning to modern China as well (Millward 2007).

Authorities of agricultural empires also frequently used migration type C (allied marriage) as a political approach to achieve peace on the frontiers with nomads (Pan 1992; Di Cosmo et al. 2018). These arranged marriages resulted in significant population transfers of accompanying retainers and other colonists. As was the case elsewhere in Eurasia, the goal was the pacification of hostile neighbors through kinship. The use of allied marriages occurred from the Han Dynasty until the Song Dynasty (Wright 2011). Although the Song Dynasty declined the Liao request of marriage alliance, Song authorities sent a larger silk and precious metal subsidy (Pan 1997). Allied marriage could guarantee peace and the stability of alliances in the long term (Raaflaub 2007). During dry periods, the tension between nomads and agriculturalists increased as a result of a general decrease in bio-productivity. Therefore, more allied marriages were implemented by an agriculturalist empire.

For migration type D (agriculturalists' attacks on northern nomadic minorities), most conflicts between pastoralists and agriculturalists happened during dry periods. The same lack of precipitation that negatively affected farmers' harvests also made less grass available for the nomads' animals. Higher aridity was a stressor for both kinds of societies and caused population movements in both. These movements generated violent conflict between the two groups over a precious resource: land that could grow grasses either for agriculture (wheat) or for pastoralism (fodder). When nomads moved south toward greener pastures, agriculturalists fought back to regain lost territory (D. D. Zhang et al. 2015). Migration type D thus sharply increased during dry periods.

These four categories of migration type cover 159 of the 195 total events and thus account for 81.5 percent of the total recorded migration events in the study period of 200 BC to 1400 AD, although those of migration type B were almost equally frequent during dry periods if compared with the other three types. Such results imply that the history of northwesterly migration among agriculturalists is not stochastic or linked to the particular policies of individual dynasties but rather a decision often related to climate change and the influence of climate change on nomadic pastoralists. The geopolitical relationship between agriculturalists and nomads merits further study in light of these findings.

The effects of dry climate on other migration types (E–K) are difficult to assess with such a small sample size, although these types also all occurred more frequently during dry periods (except migration type J). We are not arguing for environmental determinism nor absolving Chinese farmers for military actions directed at their pastoralist neighbors, but the careful use of a large data set of both paleoclimate and historical sources reveals the general trend on the regional level. Our approach allows not only more precision in reconstructing past climate change but also in analyzing the tangled causation of its effects on human migration. Table S.2 of the Supplementary Materials lists the detailed reasons for these categories. The extent of the nomads' influence should not be ignored when investigating these events on an individual (i.e., case-by-case) basis.

Conclusion

This study identified a pattern of northwesterly migration of farmers in historical China that differed from the farmer's main national-scale trend of southeasterly migration direction. Based on quantitative analysis, we found that northwesterly migration increased by a statistically significant result during dry periods. This condition cannot rationally be explained by the direct linkage of climate change, given the surprising inverse correlation of relevant variables in statistics. We argue that the roles of nomadic migration and invasion should be considered because of their direct connection to climate change. In dry conditions, nomadic people often migrated southward and affected the adjacent regions where agriculturalists lived (Bai and Kung 2011; D. D. Zhang et al. 2015). Temperature was found to be less important due to the geographic scope of the study, but temperature might be more important on a spatial or temporal scale different from those used in this study.

This research has at least two merits. First, the study confirmed one limitation of quantitative analysis of historical issues. Quantitative perspective in general cannot explain all kinds of historical questions. At the macroscale of time and space, a quantitative geographic approach could be reliable. When the scale narrows, qualitative historical methods should become more important. This research has demonstrated the importance of scale when bridging geography and history. Although data determinism has been criticized (Barnes 2013), this study explains the limitation of quantitative analysis in history with a detailed answer of scale thinking.

Second, this study investigated the reasons behind northwesterly migration of agriculturalists from both climatic and historical backgrounds. The novel field of environmental humanities, which offers a new paradigm of interpreting society based on environmental changes, has recently emerged (Hall 2010). Environmental humanities can help to reinterpret histories and contemporary crises, recover words and images, and create concepts necessary to reclaim common experiences of trauma and hope (Forêt, Hall, and Kueffer 2014). This study examined agriculturalists' migration away from central China and the Silk Road region under climate change. Hence, the study not only provides new insights into the research on the climate change–migration relationship but also further promotes the development of environmental humanities in practice, although environmental humanities remains at a theoretical level.

Northwesterly migration, which presents a different pattern from the major trend in the direction of agriculturalists' migration, is specifically discussed. Such differences are mainly rooted in the local social–political factors—the nomads' influence—of a regional-scale study. The combination of quantitative paleoclimate analysis and qualitative historical research allows this study to avoid the trap of environmental determinism. This study also offers avenues to explore comparable, seemingly atypical movements of agriculturalists toward aridity, into areas where clashes with nomadic pastoralists are all but inevitable. As historian Hämäläinen (2008) also showed, the Comanche nomads moved onto the U.S. Great Plains—and into conflict with their seasonally agricultural neighbors—in a moment of increased aridity in their native Great Basin. This study on historical China hence has global implications for nomadic migration under the impacts of climate change, as a study of asylum requests by Middle Eastern refugees has shown (Missirian and Schlenker 2017).

In addition to the aforementioned academic findings, this study could possibly provide historical references for One Road planning in the current One Belt and One Road Initiative. The One Road goes through many central Asian countries and arid and semiarid regions. From past empirical conditions, dry climate could alter the relationship between pastoralists and agriculturalists. The current level of climate change has not been experienced in the past millennium. Warming could reduce precipitation levels and water resources in central Asia (Sorg et al. 2012). In this context, the Chinese government must pay attention to the shrinkage of water or rainfall that could affect local political, social, or economic structures. The One Road strategy should consider these possible impacts of climate change and their chain effects. This condition could equip the potential significance of investigating historical societies from climatic influences, which could initiate planning based on an understanding of relevant past experiences (Lemos and Rood 2010), besides those significant socioeconomic factors.

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Supplemental Material

Supplemental data for this article can be accessed here.

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Notes

1. This Chinese proverb (孔雀东南飞) can also be translated as "Southeast flying of peacocks." Originally speaking, it was the work of the anonymous author of a love story. It is now used to refer to the phenomenon of preferred migration to southern and eastern China.
2. Xinjiang literally means "New Frontier" or "New Borderland" in Mandarin.
3. *Ershisi Shi* (Twenty-Four Histories; Table S.3 of the Supplementary Materials) are the Chinese official historical books covering a period of historical China. Each history was officially compiled by the successive dynasty. *Zizhi Tongjian* is a pioneering reference work in Chinese historiography, collated by the order of Emperor Yingzong in the Song Dynasty. *Siku Quanshu* is the largest collection of books on Chinese history and was commissioned by the Emperor Qianlong in the Qing Dynasty.

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