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The change of geographical distribution of two Asian species of rhinoceros in Holocene*

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Abstract—At present only five species of rhinoceros surrive in the world, among which three in Asia No wild rhinoceros has been found alive in East Asia now. But many recent evidences reveal the fact that rhinoceros still lived not very long ago in the East Asian Continent of Holocene. The attention to East Asia rhinoceros in Holocene first arose from archaeological studies on ancient ruins in China. Archaeologists first found some subfossil skeletons of rhinoceros in ruins of Yin Dynasty in Anyang of Henan in the 1930s. Then more skeletons of rhinoceros were found in many other Neolithic Ages runis, such as in Tonghai (Yunnan), Nanning (Guangxi), Xichuan (Henan), Yuyao (Zhejiang), and Haian (Jiangsu).(Guangxi Archaeological Team 1972; Jia 1977; Wu 1983; Huang and Liang 1984; Xu 1990). Moreover, Zhou Benxiong reported some rhinoceros teeth containing residual organic matter found in caves in the middle and lower reaches of Yangtze River. According to a number of very now skeletons of rhinoceros found in some caves in Central China and South China, Yang Zhongjian drew the inferences that rhinoceros might live in the Southern part of China until in the Han Dynasty (about 2000 yrs. B.P.) at least. These discoveries provided the material evidences for the distribution of rhinoceros in East Asian Continent. Recently, some scholars brought forward more new information about Chinese rhinoceros from the analysis of historical records and investigations of unearthed cultural relics respectively (Wen and He 1981; Sun 1982). Based on the above materials and informations, this paper is going to deal with the species of rhinoceros once living in East Asia from the viewpoint of zoo-geography. At last, we brouhgt up the evolution process of the rhinoceros in distribution in Asia with comprehensive analysis of physiographical elements and human activities.

Keywords: rhinoceros, geographical distribution, evolution process, East Asia, Holocence.

1. Rhinoceros' Northward Extension in Prehistorical Period

During the powerful glacial age of the Later Pleistocene with the advance of glaciers, the temperate zone became narrow. The cryoedge animal groups, which were symbolized with *Mammuthus primigenius* and *Coelodonta antiquitatis* and distributed wide in the Northern Hemisphere, extended southwards distinctly. While the thermophilous animal groups retreated obviously towards the equator.

About 11 000 years ago, the earth got into the post-glacial period. As the climate got warmer and warmer, many thermophilous animals migrated northwards in the post-glacial period. In East Asian Continent, the Holocene terrestrial mammal animal groups gradually established and

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developed and the Pleistocene cryoedge animal groups got into extinction. There were many climatic fluctuations in Holocene, but in general it can be divided into three climatic stages, i.e. early, middle, and late ones. Early Holocene stage witnessed a temperature-rising period. Some species of animals began to move northwards from the tropical zone of Asia where they had lived in the ice age. The middle stage was the warmest and moistest period in Holocene epoch. So, during this stage, many animals reached their farthest northern limitation. Late Holocene stage was a changeful period in climate. Bet it's main tendency was getting colder and many thermophilous species of animals retreated southwards.

Many evidences of fossils reveal that the earliest rhinoceros appeared as early as in Triassic and got flourishing in Pleistocene. A numner of rhinoceros fossils have been discovered in China. However, from which no direct successive realtionship with the Holocene East Asian species of rhinoceros has been found. Three surviving rhinoceros in Asia are all tropical animals. In Guangzhou, rhinoceros can not stand to the shock of cold wave and rely on the artificial heating system to survive in winter. During the Pleistocene ice ages, the temperature in East Asia was much colder than presemt. Therefore, it is certain that the Asian rhinoceros couldnot live in East Asia at that time. And the Holocene rhinoceros of East Asia might come from Southeast Asia in the post-glacial period. In the Early Holocene, rhinoceros began to extend their living region from low latitude area towards north. The push was quite fast. At least, at the time of about 7000~6000 years ago, the rhinoceros had arrived the latitudes of about 30°N. For example, their skeletons were discovered in the cultural horizons of corresponding period both in the ruins of Hemudu (30°N) and Xiawanggang (33°N). In the Atlantic climatic period, the warmest in Holocene, the north bounditions, especially the blocking of Qinghai-Tibet Plateau and Yunnan-Guizhou Plateau, the distribution of rhinoceros was limited to the south and east of the above plateaus.

II. Species of Rhinoceros in East Asia

The species of Holocene rhinoceros in East Asia is still a contentious problem. Both Wen (1981) and Wu (1983) believed that all three species of rhinoceros, *Rhinoceros unicornis*, *Rhinoceros sondicus* and *Didermocerus sumatrensis* living in Asia now once existed extensively in East China. Till now, from the unearthed skeletons only *Didermocerus sumatrensis* and *Rhinoceros sondicus* have been certainly identificed. Therefore, the viewpoint that *Rhinoceros unicornis* once lived in East China is lack of objective evidences to support it and is still a subjective deduction. Based on the viewpoint that the Holocene rhinoceros of East Asia came from the tropics, we discuss the problem about their species further.

There are some differences in ecological features among three species of Asian rhinoceros. *Rhinoceros unicornis* usually living in mud-marsh and high-grass plains is large in size, slow in movement, and poor in climbing ability. *Rhinoceros sondicus* usually living in lowland-rainforests is smaller than *Rhinoceros unicornis*, and is able to climb up to an altitude more than 1000 meters. *Didermocerus sumatrensis* usually living in mountain-rainforests is the smallest but the most active among these three species and is able to run on high steep slopes. In addtion, it's hairy skin make it possible survive in a colder ervironment.

In the geographical distribution of animals in Asia, there is an aspect which has not been noted yet. It is the geomorphic blockage that effects the terrestrial animals exchange between Southeast Asia and South Asia. From the eastern end of the Himalayas to mountains in west of Burma

stands a large "fence"-mountainous belt separating India and Burma. The "fence" is not very high everywhere, but it does some work as a obstruction to the animals' exchange between both sides. It may be easy to the animals with climbing ability to through the "fence", but it is impossible to those weak in climbing such as *Rhinoceros unicornis*. It is the "fence" that controls the distribution pattern of Asian rhinoceros, e.g. *Didermocerus sumatrensis* and *Rhinoceros sondicus* distributed not only in Southeast Asia also in Bengal and Assam, i.e. overlayed the distribution of *Rhinoceros unicornis*. In contrast, the distribution of *Rhinoceros unicornis* is limited in the eastern part of South Asia and couldnot expand into the areas of other two species in Southeast Asia. *Didermocerus sumatrensis* and *Rhinoceros sondicus* could naturally migrate northwards along valleyes or low mountains and entered the East Asia. When climate was getting warm in Early Holocene, the two rhinoceros began to extend northwards from Southeast Asia to the Chinese Continent and had reached South China and Central China. As *Didermocerus sumatrensis* has a stronger ability in resistance to low temperature, its distribution should be more extensive than *Rhinoceros sondicus*.

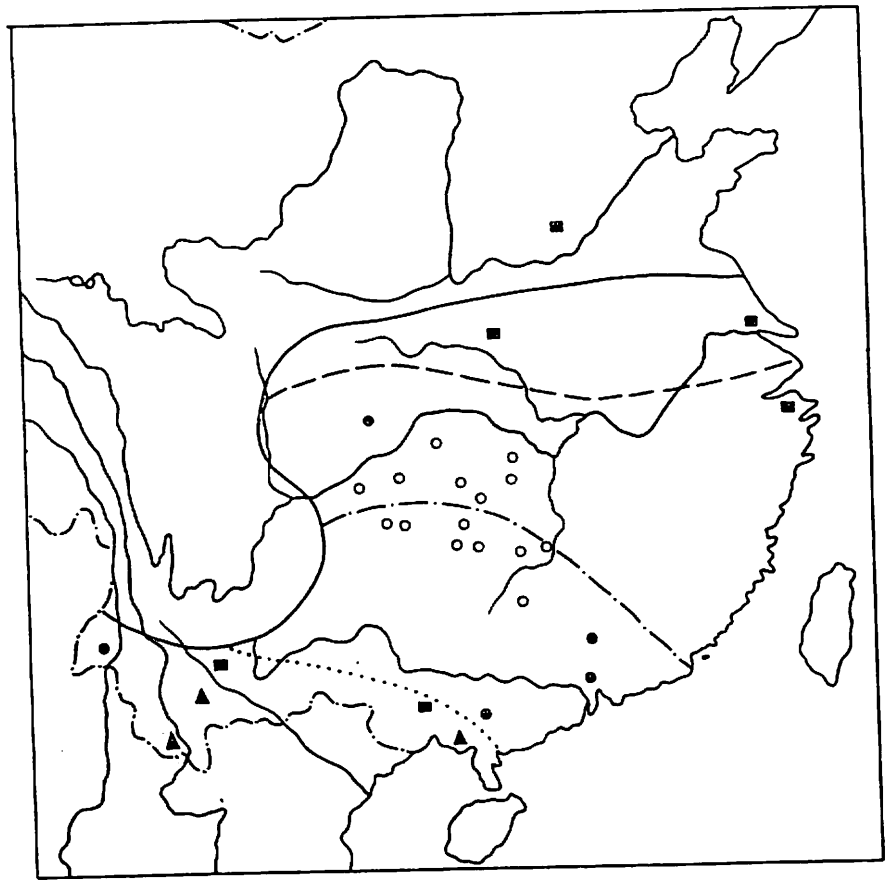


Figure 1 The evolution of rhinoceros distribution in China

III. The Southward Retreat in Historical Period

Late Holocene is a period with historical records in China. From the records there were, at least, four warm-cold cycles in East Asian Continent (Zhu 1972). But, in general, getting colder is the tendency in that stage. In addition to the climatic changes, the raise of human abilities in reforming the natural environment and hunting skills, expecially the outward push of the Yellow River civilization, made the distribution of rhinoceros retreat southwards and become smaller and smaller. Now we discussed the process in five stages as the following.

1. The stage of Yin Dynasty before (about 25000 yr. ago)

In this stage climate kept on warmer and moister for a long time. Many skeletons of rhinoceroses, elephants, tapirs, buffalos and other thermophilous animals have been discovered in the Yin Dynasty ruins in Anyang (Henan). Result of historical physical geography research showed in this stage the natural landscape of Central China Plain was characterized by forest and marsh. It did provide a suitable eco-environment for rhinoceros. Accordingly we deduced northern boundary of *Didermocerus sumatrensis* at that time should arrive in the Qinling Mountains and about of the Huai River.

2. Spring and Autumn Period (about 25000 yr. B.P.)

After Yin Dynasty, it got into a short cold period in the early Zhou Dynasty. Although it got warm again in the Spring and Autumn Period, the climate couldnot be as warm as in the Middle Holocene. Moreover, following the technical prograss of agriculture, the population in Central China increased quickly. All of the Central China were almost under cultivation. And it was also a large-scale killed period to rhinoceros. A great amount of rhinoceros were hunted for their horns and skins. Horns were used in making arts and skins were used in making soldier's armour. All these led to the decline of rhinoceros distribution. The northern boundary of rhinoceros in that stage might retreat to Sichuan Basin and the middle and lower reaches of the Yangtze River. For instance, historical documents gave many records that the Xi and Si (rhinoceros' name in ancient Chinese) appeared in the extent of Ba, Shu, Chu, and Wu (ancient states in Sichuan Basin and the plains of middle and lower reaches of Yangtze River).

3. The stage of Sui and Tang Dynasties (about 1500 yr. B.P.)

From the end of Han Dynasty to the Northern and Southern dynasties, the climate went through a new bitter cold period. After hundreds of years sustained cultivation, few areas with primitive natural environment could be left in Sichuan Basin and the Yangtze River Plains. As a result of sustained hunting, rhinoceros became more and more sparse. The distribution of rhinoceros went further southwards. In spite of the climate getting warm again during the Sui and Tang dynasties, the rhinoceros area couldnot recover. According to historical records of Tang Dynasty, counties devoting rhinoceros' horns for imperical court were all located in uncultivated hilly wilderness south to the Yangtze River. So, the northern boundary of rhinoceros distribution at that time should be between the Yangtze River and the Pearl River.

4. The stage of Ming Dynasty (about 500 yr. B.P.)

After the Tang Dynasty, especially after the Song court had to moved to the south of the Yangtze River, North and Central China fell into a tangled warfare state for a long time. To avoild the

disaster of war, a great number of people migrated to the South. Consequently, land of Jiangxi, Hunan, Fujian, and Guangdong began to be cultivated in a large-scale. Meanwhile, climate also came into another serious cold period in the Southern Song Dynatsy. Under the combined stresses of powerful human activities and cold climate, the distribution of rhinoceros shrank continuously and rapidly towards south. After the South Song Dynasty, information about alive rhinoceros was rarely mentioned and recorded in historical documents, and in the times of Ming Dynasty the average people couldnot recognized what a rhinoceros was. These showed rhinoceros lived to a limited and remote area, i.e. disappeared in most of East Asia. The distribution at the times should be limited to a narrow zone in the southern part of Yunnan and Guangxi linking to the Southeast Asia.

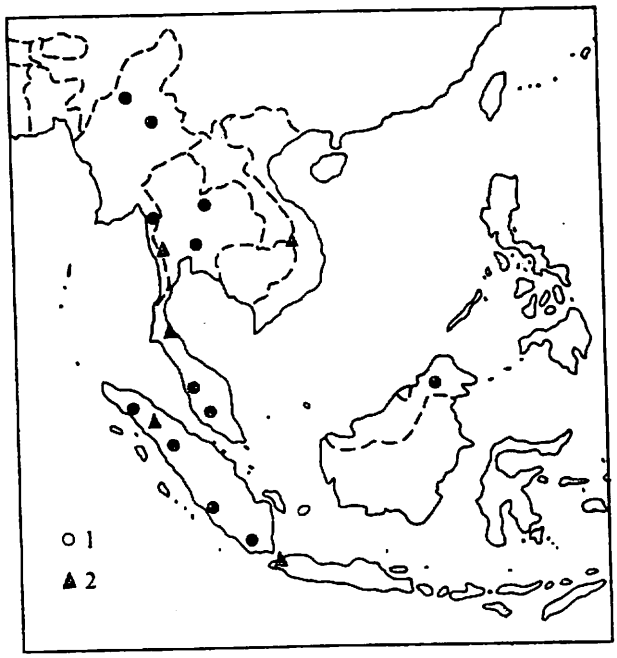
Table 1 Distribution places of rhinoceros in historical period

	Name of distribution place*	Geographical location
Places of skeletons unearthed (Prehistorical period)	1. Yinxu, Anyang, Henan	36.1°N, 114.3°E
	2. Xiawanggang, Xichuan, Henan	33.2°N, 111.5°E
	3. Qingdun, Haian, Jiangsu	32.5°N, 120.6°E
	4. Hemudu, Yuyao, Zhejiang	30°N, 121.3°E
	5. Qiluhu, Tonghai, Yunnan	24.7°N, 102.7°E
	6. Baozitou, Nanning, Guangxi	22.8°N, 108.4°E
Counties of devoting rhinoceros horns (Tang Dynasty)	7. Qijiang, Sichuan (Nanzhou)	29°N, 106.6°E
	8. Pengshui, Sichuan (Qianzhong)	29.3°N, 108.2°E
	9. Sinan, Guizhou (Feizhou)	27.9°N, 108.2°E
	10. Fenggang, Guizhou (Yiquan)	28°N, 107.8°E
	11. Yongshun, Hunan (Lingxi)	30.3°N, 109.5°E
	12. Yongshun, Hunan (Lingxi)	29°N, 109.9°E
	13. Lixian, Hunan (Liyang)	29.3°N, 111.8°E
	14. Changde, Hunan (Wuling)	29.1°N, 111.7°E
	15. Yuangling, Hunan (Luxi)	28.5°N, 110.4°E
	16. Mayang, Hunan (Luyang)	27.9°N, 109.8°E
	17. Zhijiang, Hunan (Longxi)	27.5°N, 109.7°E
	18. Qianyang, Hunan (Tanyang)	27.3°N, 1102.°E
	19. Shaoyang, Hunan (Shaozhou)	27.2°N, 111.5°E
	20. Hengyang, Hunan (Hengzhou)	27°N, 112.6°E
	21. Daoxian, Hunan (Jianghua)	25.5°N, 111.6°E
Counties of rhinoceros recorded (Tang Dynasty)	22. Quxian, Sichuan (Quzhou)	30.8°N, 107°E
	23. Yingde, Guangdong (Yingzhou)	24.2°N, 113.2°E
	24. Guangzhou, Guangdong (Guangzhou)	23.1°N, 113.2°E
	25. Yulin, Guangxi (Yulin)	22.7°N, 110.2°E
	26. Tengchong, Yunnan (Yuedan)	25°N, 98.5°E
Places of rhinoceros appearing (Last century)	27. Hepu, Guangxi	21.7°N, 109.2°E
	28. Xishuangbanna, Yunnan	22°N, 100.5°E
	29. Yuanjiang, Yunnan	23.3°N, 102°E

* Place names in brackets are ancient names in Tang Dynasty

5. The present century

In the last century, *Didermocerus sumatrensis* and *Rhinoceros sondicus* still lived widely in Southeast Asia and South Asia. To the north side, their distribution extended to Bengal and Assam in west and Viet Nam in east. To the South side, *Didermocerus sumatrensis* arrived to Sumantra and Borneo through Malaya Peninsula. *Rhinoceros sondicus* extended southwards to Malaya, Sumantra, and Java. The number of them was still very large. But this number and area have decreased sharply, since the latter half of the last century because of the usage of rifles in hunting. By the end of 1930s, the two species of rhinoceros can't be found in many places of Southeast Asia and have extinguished in China, Bengal and Assam. Today, they survive only in a few small conservation districts in Southeast Asia (Figure 2). In deed, these small groups of rhinoceros are in danger of vanishing.



1--*Didermocerus sumatresis*
2--*Rhinocerros sondicus*

Figure 2 The remanent distribution of rhinoceros in Southeast Asia

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