

STUDIES ON THE TROPICAL AND SUBTROPICAL PASTURE RESOURCES AND THEIR EXPLOITATION PROSPECTS IN CHINA

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ABSTRACT

The tropical and subtropical zone is located between 18.2-34.5° N latitude and 100-122° E longitude in southern China. Under favorable conditions, approximately 40 million hectares of the rangelands in this area show a potential for the development of animal husbandry. In recent years, the introduction of some legumes and grasses, as well as of techniques of cultivation from Australia and New Zealand has contributed to the improvement of these rangelands. The key species and the type of cultivation in different regions of this area have been basically defined, and an exploitation and improvement program is being designed. The progress made in several state farms is described and the prospects are also discussed.

China is rich in resources of native pastures. There are the North-eastern grasslands, Inner-Mongolia grasslands etc. in the northern part of China. These grasslands which cover vast expanses of territory with a total area of 280 million hectares, chiefly belong to the arid, semi-arid grassland or alpine pasture types. These have been the main districts of animal husbandry or semi-farming, semi-livestock systems in China for a long time. However, some parts of these grasslands are presently undergoing sandy, alkaline changes or are becoming deteriorated as a result of limited precipitation and over-grazing. In the south of the Qingling Mountains-Huaihe river belt, tropical and subtropical rangelands (including some parts of the temperate zone) where favorable conditions prevail, cover about 40 million hectares, and offer a potential for the development of animal husbandry. For the purpose of developing animal husbandry and establishing a balanced ecosystem with agriculture, forestry and livestock, comprehensive surveys of pasture resources in the South and the North have been separately carried out on several instances by the scientists of China. A thorough investigation on pasture resources has been basically completed and a scientific exploitation program is being planned. This paper is intended to make a brief account of the pasture resources of the tropical and subtropical zone of China.

The distribution and general situation of the tropical and subtropical rangelands in China

The tropical and subtropical zone is located between 18.2-34.5°N latitude and 100-122°E longitude, including fourteen provinces or autonomous regions in southern China. This area covers one-fourth of the total land and accounts for one half of the population of the country. The rangelands here are vast stretches, odd pieces inlaid with farmlands, or forest grasslands with an elevation of more than 1,000 meter. Most of them are located in the subtropical zone except for the southernmost areas of Guangdong, Yunnan, Fujian and Taiwan provinces which are located in the tropical zone. Bordering on the sea in both the east and south, they are affected by the warm and moist monsoon climate all the year round. In addition, the dry wind from the south is intercepted by the Tibetan Plateau in the southwest, so that this area has abundant heat and adequate rainfall. As compared with the zone in the latitude which in other parts of the world is exposed to unfavorable conditions, this area may be considered to

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be well endowed by nature.

The specific features of the rangelands in this area are as follows:

1 Under damp and hot conditions: The annual rainfall ranges between 800 and 2,000mm, and the average temperature between 16 and 25°C with an annual cumulative temperature ($\geq 10^{\circ}\text{C}$) of 4,500-9,000°C. The frost-free period lasts more than 270 days. The cover degree of vegetation is about 80-90% and the average dry matter yield 3 ton per hectare, i.e. 2-3 times more than that of the northern grasslands.

2 A longer growing period: The growing period lasts mostly 9-10 months, and growth is possible even all the year round. The productive stage may last 200 days even if the vegetation grows on high mountains, at an altitude of 2,000m.

Since the vegetation consists of tall grasses with a height of 1-1.5m, it can be used for hay-making in winter.

3 Greater potential: Though the rangelands cover a vast area, the utilization ratio is still rather low. For instance, investigations carried out in the Guangxi Autonomous Region showed that the rangelands cover one-fourth of the total land (excluding scattered areas of pasture), 2.2 times more than the area of farmland in this region. However, presently the utilization ratio is below 30%.

4 Suitable for the establishment of an ecosystem based on a scientific approach: As the rangelands in southern China are inlaid with farmland and forests, this situation is advantageous for the conservation of water and soil and the improvement of fertility, enabling the integrated development of agriculture, forestry and livestock. In addition, the large labor force and adequate transportation facilities available in this area are also conducive to the development of the processing of animal products, transportation and commerce.

However, there are also some unfavorable factors in the southern rangelands. Firstly, the grass quality of the native pastures is low. The proportion of legumes in the vegetation is small, and the dominant species such as *Miscanthus*, *Heteropogon*, *Themeda*, *Eulalia*, *Arundinella*, etc. have coarse fibers, are unpalatable and less nutritious. Secondly, as they are chiefly transitory secondary communities, there is a lack of rhizome species and thick and deep-rooted pastures cannot be established successfully. Because of the steepness of the slopes and abundance of rainfall, the soils are mostly acidic red or yellow, which become waterlogged during the rainy season. As a result, the root systems of grasses are rather shallow and cannot withstand grazing frequently.

Studies on introduction of Chinese and foreign pasture species and cultivation techniques in tropical and subtropical China

Investigations showed that in the tropical and subtropical zone of China, there are 1,467 genera of plants, which account for 51.1% of the total genera and species in China, due to the favorable ecological conditions prevailing there. In addition 80% of the legume and grass genera and species can be found in these areas. Although some valuable genera or species of plants cannot grow together to form a community, their existence is comparable to a gene bank of plants. For instances, several valuable species and samples of widely distributed genera, such as *Paspalum*, *Digitaria*, *Miscanthus*, *Dactylis*, *Medicago*, *Vicia*, *Lespedeza*, *Pueraria*, *Astragalus*, etc. and *Trifolium*, *Lotus* in high mountain areas, are well worth domesticating and breeding. In fact, domesticated legumes and grasses, such as *Alysicarpus vaginalis*, *Pueraria pseudo-hirsuta*, *Trifolium repens*, *Trifolium pratense*, *Miscanthus floridulus*, *Digitaria sanguinalis*, *Sorghum propingnum*, *Hemarthria compressa*, *Cynodon dactylon*, etc. have already been cultivated and utilized for several decades or years in the Guangdong, Fujian, Guizhou, Sichuan provinces and Guangxi Autonomous Region.

However, scientists and some state farmers have realized that the introduction of grasses

and legumes to southern China will certainly be an efficient and faster means of improving the rangelands there.

1 Adaptive distribution of valuable species and varieties in tropical and subtropical China

China has been paying great attention to the introduction of valuable species of legumes and grasses, such as Elephant grass which was introduced into the tropical zone in the early 1930s, Stylo, Townsville stylo and *Leucaena* in the 1960s, and Coastcross 1 Bermuda grass in the 1970s, etc. These species had been tested and evaluated in small plots and then popularized. Since the 1970s, under the supervision of the Institute of Animal Sciences of the Chinese Academy of Agricultural Sciences, various universities and institutions in southern China, a series of foreign pasture grasses and legumes have been introduced and tested in a planned way. Now the key species in the southern rangelands have been basically identified.

Xiong (1984) suggested that the forages cultivated in China can be classified into eight groups depending on the region, and four of them are included in the tropical and subtropical zone (Table 1).

Table 1 Classification of the regions and adapted species in the tropical and subtropical region of China

Climate zone	Regional scope	Annual temperature (°C)		Mean annual rainfall (mm)	Soil	Soil pH	
		Cumulative (>10°C)	Max				Min
Tropical zone	The southernmost areas of Yunnan, Guangdong, Guangxi, Fujian and Taiwan <i>Adapted species:</i> Stylo (<i>Stylosanthes guyanensis</i>), Siratro (<i>Macroptilium atropurpureum</i>), Leucaena (<i>Leucaena leucocephala</i>), Setaria grass (<i>Setaria anceps</i>), Buffel grass (<i>Cenchrus ciliaris</i>), etc.	7,500-9,000	38.1	2.9	1,700	Red	4
Southern subtropical zone	The central and southern parts of the former provinces. <i>Adapted species:</i> Siratro, <i>Dolichos axillaris</i> , Townsville stylo (<i>S. humilis</i>), <i>Leucaena</i> , Elephant grass (<i>Pennisetum purpureum</i>), Setaria grass, Buffel grass, etc.	6,500-8,000	39.5	-1.2	1,500	Red Yellow	4.8-5.4
Central and northern subtropical zone	The southern part of Daba Mountain, Hongzhou-Yiyang belt and the northern part of the Fuzhou-Teng-chong belt, the southern part of the Qing-ling and Huaihe rivers <i>Adapted species:</i> Paspalum grass (<i>Paspalum dilatatum</i>), Bermuda grass (<i>Cynodon dactylon</i>), white clover (<i>Trifolium repens</i>), fescue grass (<i>Festuca arundinaceum</i>), Italian ryegrass (<i>Lolium multiflorum</i>), Cocksfoot grass (<i>Dactylis glomerata</i>), reed canary grass (<i>Phalaris tuberosa</i>), etc.	5,000-6,000	40.5	-13	1,000-1,500	Red Yellow	4.5-5.5
Plateau of central and northern subtropical zone	Same as former regions at an altitude of 1,200-3,000 m <i>Adapted species:</i> white clover, red clover, perennial ryegrass (<i>Lolium perenne</i>), Cocksfoot grass, reed canary grass, etc.	4,500	30	-8	1,500-2,000	Laterific and loesslike loam or meadow soil	5.5

It was demonstrated through the introduction of foreign species that some species from northern Australia are very suitable for the tropical and southern subtropical zone of China. A set of valuable species and varieties from Australia was selected and evaluated by the Livestock Institute of Guangxi in 1974. Since 1981, experts from Australia in cooperation with Chinese specialists have successfully established a large area of artificial pasture in the Orient State farm, Hainan Island, Guangdong province, by using Kazungula, Buffel grass, Siratro, Stylo and shrubby Stylo. At the same time, an improved pasture consisting of a mixture of Kazungula, green panic grass, Siratro, *Dolichos axillaris* and Stylo has been established in the Qianjiang State farm in Guangxi. Rangeland improvement has also been successful in Banling Livestock Farm, Dongguan Country by using molasses grass and Townsville stylo. The species introduced from New Zealand which are suitable for a temperate moist climate, such as *Trifolium repens*, *Lolium perenne*, *Dactylis glomerata*, *Lolium multiflorum*, *Trifolium subterraneum*, and *Lotus uliginosus*, etc. are also suitable for cultivation in the highlands of the subtropical region. For example, since 1980 perennial ryegrass and white clover from Australia and New Zealand, Huia white clover from New Zealand, have already been established and account for a large area of pastures with high yield and good quality in the Nangshan Livestock Farm, Hunan province, and Weining County, Yunnan province, respectively. Besides, temperate species from UK, Denmark and the Netherlands, and the Mexican Cornlike crops (an annual forage crop) from Japan in 1979 are also suitable for the subtropical and tropical regions of China.

2 Key factors for the cultivation of valuable species of legumes and grasses

Seed treatment and inoculation: A number of legumes with hard seed-coat, such as Siratro, Stylo, *Leucaena*, etc. show a low rate of germination and it is necessary to treat the seeds with hot water or scarification through rubbing. Legume seed should be inoculated with *Rhizobium*. The seed-ball made by mixing the seeds with *Rhizobium*, molybdenum and superphosphate can give good results especially in aerial sowing.

Seeding pattern: In small plots, sowing is usually performed in the lines or holes, or by manual broadcasting. Sometimes asexual propagation is used in legumes and grasses to promote establishment. In the large areas, sowing of grass/legume mixture can be performed mechanically on a flatland or a gentle slope, whereas on steep slopes, burning or excessive grazing, occasionally spraying of herbicides is needed before aerial seeding is performed. For removing the luxuriant native vegetation and preparing the seeded, fine ploughing and harrowing are preferable to surface cultivation.

Application of phosphorus: Phosphorus deficiency is common in the southern China soils. A quantity of 150-250kg of super-phosphate per ha is usually required for pasture establishment. In the strongly acidic soils, liming (3-7 ton per ha) is quite practical.

Fertilizer nitrogen: Nitrogen is of vital importance for the growth of grass, but it remains difficult to use it economically. In certain cases, 5-15 ton of compost per ha can be spread if the sowing area is not too large.

Control of grass diseases: The problem of diseases and pests of introduced grass is not serious for the time being. However a sward of Stylo was destroyed by *Colletotrichum trifolii* in Guangxi in 1983. Thus screening and quarantine procedures are necessary for the introductions.

Fencing management: Most of the species grow slowly during the seeding stage. Even if the pasture is established, rotational grazing or cutting should be performed for increasing the productivity. Fencing in a large area of artificial pasture is also important.

3 Several examples of rangeland improvement

Rangeland improvements have been promoted in different regions of southern China in recent years. The results of several examples are shown in Table 2.

Table 2 Studies on the dynamics of pasture improvement in some state farms

State farms	Climate zone	Environment	Year and country of origin	Progress
Nanshan (Huana province)	High altitude subtropics	Altitude 1,500-1,800m Annual temperature 11°C Annual rainfall 2,000mm Soil: pH4.5-5.5 Acidic Yellow	1980, Australia	18 of 29 species and varieties have been selected since 1975. A large area of ryegrass/clover mixed pasture has been established since 1929. Now the productivity of artificial pasture is 4-5 times higher than that of native pasture. Withering period of grass is two months less than before.
Q i a n j i a n g (Guangxi Autonomous Region)	South subtropics	Altitude 100-150m Altitude 100-150m Annual temperature 20.7°C Annual rainfall 1,420mm Soil: pH4.8-5.4 Red, Brown Clay	1980, New Zealand	7 of 10 Australian species and varieties have been selected. Five treatments were tested: sowing in drills by machine; ploughing and harrowing before aerial seeding; burning before aerial seeding and aerial seeding without treatment. The relative productivity of the first cut in the second year was 100, 80, 62, 57, and 26 respectively. The proportion of cultivated species was 86, 65, 25, 17 and 5 in appropriate treatments.
Orient (Guangdong province)	Tropics	Annual temperature 25°C Annual rainfall 1,000mm Soil: pH4 Red	1981, Australia	9 species of legumes and 9 species of grasses from Australia were selected. The best pasture mixtures are: Siratro+Cook stylo+Kazungula on sandy loam, Graham stylo+Hook stylo+Buffel on sandy soil. Application of 300 kg of fertilizer phosphorus per ha could be most beneficial.

Orientation of utilization of rangelands in the tropical and subtropical zone of China

1 Making rational use of the pasture resources

Basically the improvement of the rangelands is in the early stage, and will take a long time and require heavy investment. Particular attention should be paid to the scientific management of native pastures at present. For example, division of the grazing seasons on pasture, i.e. grazing on hills in summer and on valleys in winter to use natural topography for rotational grazing, can cut down the grazing pressure, ensure the recovery of native grass after grazing and prevent soil erosion and deterioration of the plant communities. Hay-making is also important as a supplement in winter for offering the animal balanced feed yearly. The carrying capacity would obviously be increased if these measures were taken.

2 Speed up the improvement of the rangelands through fencing and sowing

There is ample evidence that artificial pastures can increase the production and improve the quality of grass, and greatly raise the animal productivity per unit area. For instance, milk production of cows grazed in a red clover pasture increased by 49.5 percent as compared with that in native pastures in the Xiaoshao Cattle Farm, Yunnan province. Both in the Zhaopu Commune, Weining County, Guizhou province where 600 ha of red clover were seeded and Xundian Sheep Farm where 200 ha of perennial ryegrass were seeded, the carrying capacity averages 15 sheep per ha. Usually, 2 or 3 ha of native pasture are needed for feeding one cattle, whereas only 0.5 ha in an artificial high-yielding mixed pasture. Thus the improvement of the rangelands in the southern part of China is an irreversible process. Studies and field observations have led to the conclusion that a number of different introduced species and varieties could be adapted in different regions, although further selection and development of new varieties, accumulation of more data on management of improved pastures in a large area and improvement of the systems for seed production and technical extension are necessary. However, there is a dearth of trained personnel in this field and exchanges with advanced countries and training of qualified scientists and technicians are urgently needed also.

Fencing is one of the key factors for rangeland improvement. Use of the natural topography or local materials, or biological fences may reduce the construction cost.

3 Establishment of an ecosystem for rangeland farming based on a scientific approach

As stated above, there is a natural landscape in southern China, which incorporates farmland, forest and rangeland. It is a strategic task to establish a high-yielding ecosystem based on a scientific approach for the integrated development of farming, forestry and livestock. Professor Ren (1983) pointed out that several types of production systems may be developed under different ecological conditions in southern China, such as a small-scale rangeland farming system consisting of farmland and artificial or semi-artificial pastures; a large-scale system can be established through the combination of forest, pastures and farmland; and a more complicated and more efficient system can be formed by incorporating large areas of farmland, forestry, and rangeland. Studies on some of these suggestions are now being undertaken.

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Discussion

Kawanabe, S. (Japan): 1. What are the key species you cultivate in the tropical and subtropical areas of China? 2. Could you give some details about the integration of forestry and farming in your country?

Answer: 1. Stylo and Siratro are the best adapted legumes in the tropical zone. In the subtropical area, in the highlands, clover is the most suitable legume. 2. Research is still limited but we are aware of the importance of this problem.

Kitamura, Y. (Japan): It is known that 80% of the legume genera are present in subtropical China. Are there any species that have a potential for pasture use? In particular, are there any trials to evaluate the performance of *Desmodium*?

Answer: We introduce species from overseas and at the same time we collect and evaluate our local resources since 80% of the legumes are found in this area. The species which have a potential for pasture are *Gliricidia*, *Trifolium* and *Astragalus*.

Mendoza, R.C. (The Philippines), **Comment:** Based on experiments conducted at CIAT and CSIRO two indigenous species of *Desmodium*, *D. ovalifolium* and *D. heterocarpus* offer a potential for pasture crops.

Cocks, P.S. (ICARDA): We have observed that when we introduce species from other countries it is very difficult to promote seed production. What is the development of seed production in China?

Answer: Seed production systems have not yet been intensively developed in China.

Cocks, P.S. (ICARDA), **Comment:** The native species of legumes you referred to previously would be very important in the Middle East.

Have you compared the effect of rotational grazing with that of continuous grazing in terms of the stocking rate? I am asking this question because based on my own experience, I feel that continuous grazing, so long as the stocking rate is controlled is superior to rotational grazing in terms of production. In other words, in taking account of the high cost incurred by fencing, I wonder if rotational grazing is necessary.

Answer: Fencing management in some cases is important due to the high density of population.

Kitamura, Y. (Japan), **Comment:** There are two aspects to consider when you compare continuous to rotational grazing. Rotational grazing is important in small areas with

limited land and a dense population. On the other hand, when the area is large, continuous grazing is suitable.