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Population Characteristics of *Drepanostachyum ludianense* in Karst Area of Guizhou, China

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Karst habitat, as a kind of fragile ecology environment, has some typical characters such as shallow and less soil, high rate of bare stone, serious soil erosion and few soil nutrient content. However, *D. luodianense* can distribute and grow well in Karst regions.. In this study, ecological characteristics of *D. luodianense* were studied in the Karst microhabitat by field investigation and comparative and system analysis. The results showed that there was a series of adaptive features for Karst environment in *D. luodianense* population. It has high shoot-emergence number and mortality rate and low growing rate, and these features mainly result from nutrition shortage. Our finding may not only provide theoretical direction for the protection and development of *D. luodianense*, but also benefit species selection and reasonable collocation in the process of rocky desertification in Karst area.

Key words: Bamboo; Biodiversity conservation; Endangered mechanism; Ecological restoration.

Drepanostachyun luodianense which is anendemic specie in Chinacan only distribute and grow well in Karst regions[1]. At present, it is listed as an endangered species in China. *D. luodianense* usually grows on stony mountain (altitude 600-1000m) as a small population. Karst habitat is a kind of fragile ecosystem, and most plant species couldn't grow in Karst regions due to the barren soil and severe climate condition, but *D. luodianense* can grow well especially at some high slopes. So it plays a great role in ecological restoration for Karst area. *D. luodianense* is an important economic bamboo and widely used as the material for producing dead stock.

China has the biggest Karst region in the world, and tits area is over 1.24 million km^2. Karst landform is mainly distributed in Guizhou, Guangxi, Yunnan, Sichuan, Hunan, Hubei, Shanxi, Hebei and Shandong provinces[2]. The largest Karst region is in Guizhou, and the areais over 550 thousands km^2. In the south, Karst region has great ecological limitation for species, as seasonal and provisionality drought often occur[3]. Because microhabitats heterogeneity is high, it's difficult to be restored if the ecological balance was disturbed. In recent years, stony desertification appears in Karst regions, especially in Guizhou, and it tends to extend. Thus,ecological restoration for Karst region has become research hotspot. Growing plant is a feasible way to ecological restoration , but most plants can not grow in the barren soil[4-6]. During the ecological restoration, plant species selection and management are considered as the primary and crucial problems[6-9].

D. luodianense is a major specie in the south of Karst region in Guizhou, and can constitute a big population. Because of its great economic value, it is a suitable species for ecological

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restoration in Karst region. *D. luodianense* grows well in Karst region and is also distributed in stony mountain, indicating that it can adapt to the fragile ecosystem. So far, most studies just focus on edible bamboo, while tree and shrub are studied extensively. However, less attention is paid to vines bamboo, but noteworthy, it could grow and extend rapidly. Vine bamboo is more likely suitable for ecological restoration in Karst region with stony desertification.

Previous studies have reported the biological and physiological characteristics in bamboo, but less information about vine bamboo can be found. In our study, we studied the population characteristics and dynamics of *D. luodianense,* which can provide critical reference for ecological restoration in Karst region with stony desertification and biological conservation for this endangered species.

MATERIALS AND METHODS

Characteristics of population growth and development

During shoot emerging stage of *D. luodianense*, we designed three quadrats (20m ×20m) in its classical distribution region and measured the number and cover of each clone. According to our observation, *D. luodianense* shoot emerged from late period of August to late period of October. So we measured the population growth dynamics from the 15th august to the 31th October, 2008. We measured the number, height and basic diameter respectively in emerged, degraded, lively shoot, and adult shoot. Thirty bamboos were selected to measure the height on the same time in each day from 15th August. Ten young shoots which emerged at the same time were also selected to measure height respectively at three stages (early, middle and late stages). We continuously measured bamboo height per two hours on the 1th September, 18th September and 3th October.

Characteristics of population structure and aboveground biomass

In November 2007, we constructed 128 quadrats (2m ×2m) including two habitats (foreside and underpart of slope) and measured age, basic diameter, height of each bamboo. We measured aboveground biomass through indirect method. We assayed the mean height and basic diameter from each age class. Then 50 bambooes from each age class were chosen for measuring the fresh weight of each part, and then they were dried at 80°C for measuring dry weight. Water concentration of each part was calculated (leaf, branch and stem). Plant materials were separated by age class (1 year), diameter(0.lcm) and height (1m). The quadrats (2m ×2m) were chosen in cultured and natural forest.

RESULTS

Characteristics of population growth and development

Characteristics of shoot emergence

D. luodianense shoot emerged from August to October, and it lasted for about 60 to 70 days. As for the shoot emergence of temporal pattern in 2008 (Fig.1), its duration was 68 days from 18th August to 24th October. The shoot emergence would be divided to three stages according to the number of emerged shoots: (1) early stage, from 18th August to 4th September, the number of emerged shoot is 46/80m^2, which accounts for 15.38% of total emerged shoot of three stages. The mean number of emerged shoots per day is 2.6/80m^2; (2) vigorous stage, from 5th September to 28th September, the number of emerged shoots is 162/80m^2, which account for 54.18% of total emerged shoots of three stages, and the mean number of emerged shoots per day is 6.8/80m^2; (3) late stage, from 19th September to 24th October, the number of emerged shoots is 32/80m^2, which account for 10.70% of total emerged shoot of three stages, and the mean number of emerged shoot per day is 1.2/80m^2.

Characteristics of shoots maturing into bamboo

The temporal pattern of shoots maturing into bamboo was recorded (Table 1). Height growth of *D. ludianense* in different shoot emergency periods was recorded (Table 2) and it showed that height increase at early stage is the greatest, whereas the lowest height increase was observed at late stage. Temporal pattern of base diameter of the bamboo shoot was detected (Table 3), and the result suggested that there is no significant difference in base diameter of the bamboo shoot among three stages. We performed the height growth curve of *D. luodianense* young shoot by recording height change for 60 days (Fig. 2). By measuring the height of 10 shoots per two hours for one day (one day of each stage), daily height growth pattern of young shoot of *D. luodianense* was obtained (Fig.3). It was clear that shoot grew more rapidly at night than in day.

Characteristics of degraded shoot

The temporal pattern of degraded shoot is shown in Table 4. The degraded rate of *D. luodianense* shoot was low (36.55%), indicating that it was a vigorous bamboo. Height pattern of

Table 1. The temporal pattern of shoots maturing into bamboos of *D. Luodianense*

Stage		Number of shoot emerged	Number of shoot matured (%)	The rate of shoot maturing into bamboo
Early stage	8.18~8.23	5±0.12	3±0.24	60.00
	8.24~8.29	12±0.23	8±0.34	66.67
Total for early stage		17±0.35	11±0.48	64.71
Vigorous stage	8.30~9.4	29±0.62	18±0.87	62.07
	9.5~9.10	32±1.34	24±1.00	75.00
	9.11~9.16	50±1.23	41±1.67	82.00
	9.17~9.22	45±2.41	33±1.23	73.33
	9.23~9.28	35±1.32	25±0.78	71.42
	9.29~10.4	21±0.34	13±0.21	61.90
Total for Vigorous stage		212±2.26	154±1.44	72.64
Late stage	10.5~10.10	12±0.25	5±0.31	41.67
	10.11~10.16	10±0.23	4±0.14	40.00
	10.17~10.22	6±0.35	1±0.23	16.67
	10.23~10.28	4±0.12	1±0.34	2.38
Total for Late stage		32±0.48	11±0.18	34.38
Total for three stages		299±3.42	176±2.64	58.86

Table 2. The height growth of *D. ludianense* in different shoot emergency periods

Stage	Height(cm)										Mean
Early stage	315	346	313	327	322	354	297	331	364	314	328.30±20.80
Vigorous stage	244	293	283	293	276	317	289	291	271	258	281.50±20.47
Late stage	160	113	151	121	143	121	187	141	149	161	144.70±22.34

Table 3. The base diameter of the bamboo shoot of *D. luodianense* in different periods

Quadrat	Early stage	Vigorous stage	Late stage
1	0.61±0.07	0.54±0.05	0.46±0.04
2	0.57±0.13	0.58±0.02	0.44±0.06
3	0.76±0.11	0.59±0.07	0.49±0.02
4	0.71±0.05	0.51±0.05	0.45±0.07
5	0.60±0.16	0.55±0.05	0.50±0.08
6	0.63±0.04	0.52±0.06	0.49±0.07
7	0.78±0.06	0.57±0.07	0.41±0.05
8	0.68±0.06	0.60±0.04	0.45±0.08
9	0.61±0.09	0.61±0.01	0.49±0.02
10	0.53±0.12	0.49±0.05	0.41±0.08
Mean	0.65	0.56	0.46

degraded shoot of *D. ludianense* was in Table 5, and it is clear that higher shoot had lower degraded rate.

Characteristics of population structure and above ground biomass

Above-ground standing crop biomass of different age-class ramet of *D. luodianense* was recorded in different habitats (Table 6), and it suggested that two-year shoot biomass was the highest and one-year shoot biomass was the lowest. The biomass from different habitats was significantly different, and the shoot biomass in the underpart of slope was significantly higher than that of foreside of slope (Table 6).

Table 4. The temporal pattern of degraded shoot of *D. luodianense*

Stage		Number of eemerged shoot	Number of degraded shoot	Rate of degraded (%)
Early stage	8.18~8.23	3±0.23	2±0.19	66.67
	8.24~8.29	9±0.34	3±0.22	33.33
	8.30~9.4	20±1.24	5±0.12	25.00
Total for early stage	32±1.63	10±0.45	31.25	
Vigorous stage	9.5~9.10	32±1.34	5±0.13	15.63
	9.11~9.16	52±1.14	10±0.21	19.23
	9.17~9.22	42±1.71	12±0.12	28.57
	9.23~9.28	34±1.12	16±0.42	47.06
Total for Vigorous stage	160±3.42	43±0.84	26.87	
Late stage	9.29~10.4	24±0.56	15±0.12	62.5
	10.5~10.10	13±0.45	8±0.24	61.54
	10.11~10.16	10±0.26	7±0.12	70.00
	10.17~10.22	6±0.46	5±0.14	83.33
	10.23~10.28	4±0.12	3±0.35	75.00
Total for Late stage	57±0.64	38±0.35	40.35	
Total for three stages	249	91	36.55	

Table 5. The height pattern of degraded shoot *D. luodianense*

Degraded height (cm)	Number of degraded shoot	Rate (%)
<10	15±0.62	16.13
10—20	23±0.86	24.73
20—30	26±1.12	27.96
30—40	16±0.12	17.2
40—50	10±0.12	10.75
>50	3±0.43	3.23
Total	93	100

Table 6. The above-ground standing crop biomass of different age-class ramet of *D. luodianense* in different habitats (g/m²)

Age	Foreside of slope			Underpart of slope		
stage	Biomass of stem	Biomass of brance and leaf	Total biomass	Biomass of stem	Biomass of brance and leaf	Total biomass
1a	3803±21.4 (89.61%)	441±3.5 (10.39%)	4244±15.2 (100%)	5972±42.3 (89.90%)	671±4.1 (10.10%)	6643±30.2 (100%)
2a	22367±91.2 (96.96%)	701±5.1 (3.04%)	23068±41.3 (100%)	21923±48.7 (73.16%)	8043±281 (26.84%)	29966±32.3 (100%)
3a	15534±43.4 (90.06%)	1715±7.8 (9.94%)	17249±63.4 (100%)	21753±32.2 (87.13%)	3212±31.2 (12.87%)	24965±71.4 (100%)
4a	9243±30.1 (79.37%)	2412±4.5 (20.63%)	11655±36.7 (100%)	18034±34.1 (74.62%)	6134±41.3 (25.38%)	24168±31.2 (100%)

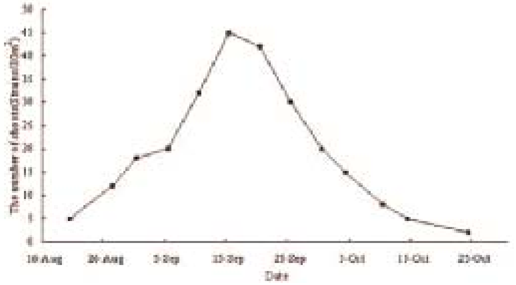

Fig. 1. The temporal pattern of shoot emergence of *D. Luodianense* in 2008

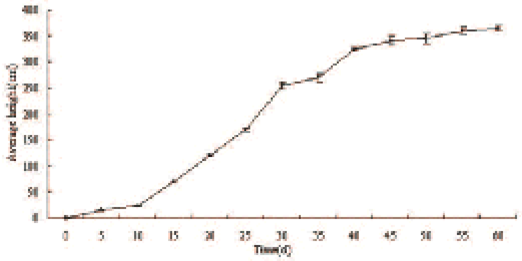

Fig. 2. The height growth curve of *D. luodianense* young shoot

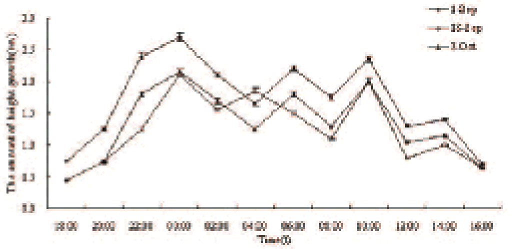

Fig. 3. The daily height growth pattern of *D. luodianense* young shoot

DISCUSSION

Our study indicated that *D. luodianense* had a series of adaptive characteristics for the environmental condition of Karst region. The characteristics of shoot emergence, shoot maturing, shoot degradation, population structure and aboveground biomass in *D. luodianense* were similar with those in other bamboo species. From shoot to adult plant, shoot number of *D. luodianense* followed the “few-many-few” trend. The duration of basic diameter growth was short. *D. luodianense* has stable basic diameter (0.46cm~0.65cm), and it did not significantly change during the study period.

The height increase of *D. luodianense* followed the "slow-rapid-slow" trend and the growth at night was significantly higher than that in day. It was similar with the growth pattern in other bamboo species[10, 11] but was different with the study on Moso bamboo[12].

D. luodianense shoot has high emerging rate and low degradation rate, the rate of shoot degradation was constant (36.25). At early stage, the shoot degradation rate was higher because of the impacts of environment and mother bamboo. The rate of shoot maturing is lower at early stage. At vigorous stage, the rate of shoot degradation is low because the shoots could absorb abundance nutrients from environment and mother bamboo. However, at late stage, the rate of shoot degradation was high, since most nutrients were supplied for height growth[11, 13-15].

Increased height of *D. luodianense* led to the decreased rate of shoot degradation. Rate of shoot degradation was very low, which was similar with studies on other bamboo species[16].

It was found in this study that mechanical damage by human and domestic animal was limited, because the local denizen improved their perception on environmental protection. So the main reason for shoot degradation was shortage of nutrient and space. In the future, it is very important to study shoot degradation from physiological aspects, which can provide crucial information for the management of *D. luodianense* artifical forest.

In conclusion, population characteristics and dynamics of *D. luodianense* ensured its adaption to the Karst environment. It was very important for the protection and development of *D. luodianense* and biological conservation for this endangered species.

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