Effects of clint on the distribution and leaf phenotypic variation of a dominant plant *Lindera communis* in Maolan Karst National Natural Reserve, SW China

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Abstract. The heterogeneous habitat plays an important role in the conservation and restoration for rare and endangered plant species. In the karst area, the clints usually cause the soil differentiation of physical and chemical properties, which affect the distribution and adaptation strategy of dominant plant populations. To study the distribution and adaptation strategy of the dominant plants in heterogeneous habitats induced by clints, we investigated the leaf phenotypic variation along the transect from *Lindera communis* plant to clint (0 cm, 0.1 cm-10 cm and ≥ 10 cm) within the Maolan Karst National Nature Reserve, Libo County, Guizhou Province, China. The results showed: (1) 483 individuals of *L. communis* had been recorded, and the trees (DBH ≥ 1 cm) were 374 individuals (77.43% of the total). The DBH of biggest *L. communis* was 10.5 cm, which was 6 cm away from the clint. In the 0 cm distance group, the tree (mean DBH 2.97 ± 1.71 cm) were 200, and the seedlings and saplings were 29. In the 0.1 cm-10 cm distance group, the tree (mean DBH 2.75 ± 1.62 cm) were 50, and the seedlings and saplings were 44. In the ≥ 10 cm distance group, the tree (mean DBH 2.52 ± 1.29 cm) were 124, and seedlings and saplings were 36. The mean DBH of *L. communis* individuals was decreased with the increase of the distance between plant and clint. The coefficients of variation of *L. communis* individuals DBH in each distance group, which indicated that the DBH distribution of this species was uncertain at different groups. (2) The leaf length, width, width/length and thickness of *L. communis* was 79.71 ±12.95 mm, 30.17 ±6.68 mm, 0.38 ±0.07, 0.24 ±0.05 mm, respectively. The petiole length and diameter of *L. communis* was 6.65 ±1.87 mm and 1.19 ±0.63 mm, respectively. The coefficient of variation of petiole length increased first and then decreased with the distance from clint increasing. Meanwhile, the variation coefficients of leaf length, leaf width, leaf width/length, leaf thickness and petiole diameter decreased first and then increased with the increase of distance from clint. The distance between the clint and *L. communis* had significant effect on the leaf length (P<0.05), and thickness (P<0.01) and width/length (P<0.01), and had minor effect on the other leaf traits. The present study highlighted that the clint had a profound influence effect on the distribution and leaf characteristics traits of *L. communis*. Therefore, we can use the clint as a key node to protect and restore the plant population size.
1. Introduction
The genetic result and adaptive evolution of plants can predict directly by the phenotypic traits [1]. Plant leaf is not only the indices which are used to explain the species filtering by environmental and the species distribution pattern [2], but also the indicators that are the most intuitive, measurable and operable[3]. The leaf traits have been used widely in the rare and endangered plants classification and conservation [4], choose species for ecosystem restoration [5] and the mechanism of alien species invasion [6], and so on.

There are a large number of clint exposed in the karst area. The clint cut the soil discontinuous and redistributed the soil moisture [7, 8] and nutrients [9] by the funnelling effect [10]. As a result, the species distribution pattern [11] and plant leaf phenotypes [12] were changed. The plant species adapted to the karst habitat with very different adaptability. Study the distribution and adaptation characteristics of the dominant plants in heterogeneous habitats can not only deepen the understanding of karst plant communities and plant adaptation, but also provide the scientific basis for species selection in vegetation restoration to help with rocky desertification controlling.

As a suitable [13] and typical pioneer species [14], the plant *Lindera communis*, which belongs to the genus *Lindera* in Lauraceae, is a dominant species in the karst secondary natural forest [15, 16]. Because the fruit, branches and leaf is valuable [17, 18], the *L. communis* is worth to conservation and development. However, the current studies have focused on the community structure [19, 20], litters decomposition [14], seed dormancy and germination [21] and chemical components [22], etc. However, the adaption strategy of *L. communis* is still unknown in karst regions. There, the present study took the *L. communis* population as an example, investigated the leaf phenotypic variation of *L. communis* and the distance between plant and clint in Maolan Karst National Nature Reserve, Libo County, Guizhou Province of Southwest China. The aims were to (1) the effect of clint on *L. communis* population distribution pattern, and (2) the effect of clint on the leaf phenotypic traits of *L. communis*.

2. Materials and Method

2.1. Study area
The Maolan Karst National Nature Reserve (hereafter referred to as Maolan, 107°52′10″-108°45′40″ E, 25°09′20″-25°20′50″ N, 430 m–1078 m) is located in Libo County, Guizhou Province, China. The reserve is a typical karst fengcong landform with rugged terrain and steep mountains [15]. It’s in the subtropical monsoon humid climate zone. The annual average temperature, sunshine hours, and precipitation of Maolan is 15.3℃, 1272.8 hours and 1750mm. The average temperature in January and July of Maolan is 5.2℃ and 23.5℃, respectively. The main soil of Maolan is limestone soil and the vegetation is typical karst evergreen and deciduous broad-leaved mixed forest with discontinuous cover.

The *L. communis* population is a dominant species in the more karts plant community of Maolan [15, 16]. These communities can be divided into three layers, in which the maximum height of the tree layer is 8 m with a canopy density of 80%. The main species of tree layer are *L. communis*, *Clausena dunniana*, *Loropetalum subcordatum*, etc. The shrub layer is about 1.3m-2.2 m with a coverage about 30%, and the main plant species are *Myrsine semiserrata*, *L. communis*, and so on. The herbaceous layer is about 20 cm with coverage about 50%, and the main plant species are *Carex chinensis*, *Selaginella doederleinii*, etc. The number and area of clints were affected by altitude (Table 1).

| Altitude (m) | Number | Area(m²) | Height(m) | Length(m) | Width(m) |
|--------------|--------|----------|-----------|-----------|----------|
| Plot 1       | 815    | 2.47±0.72| 0.79±0.67| 2.05±2.22| 0.78±0.98|
2.2. Sample design

2.2.1. Distribution pattern survey. To study the distribution pattern of dominant population *L. communis* in the communities, a total of 5 transect plots with 40m×10m were designed and each transect was divided into 4 quadrates of 10m×10m. In each 10m×10m quadrates, the plant species taxonomic name, DBH (diameter at breast height), height and the distance between the plant basal and the nearest clint had been recorded. The plant name and distance with the nearest clint of shrub layer had been investigated within 2m×2m quadrate and seedling layer within 1m×1m quadrate. To ensure the accuracy of distance between plant and clint, three people estimated the distance and verified the measurement with 5M steel tape, and the person who with the smallest error between the estimation and measurement completed the measurement of all the distance.

Some studies showed the most suitable for plant cultivation with clint is in north direction [7], which has been used to predict the soil potential of moisture and nutrients around clints. To explore the leaf phenotype adaption to the heterogeneous habitat, the distance between plant and clint without orientation had been divided into 3 groups (0 cm, 0.1cm-10cm, ≥10cm).

2.2.2. Leaf phenotypic measurement. More than 10 trees (DBH ≥ 5 cm) of *L. communis* individuals in each group (0cm, 0.1cm-10cm and ≥10cm) had been selected. And more than 10 health leaves within upper-canopy of each trees that expanded under full light conditions had been collected [23]. And then brought to lab to measure the phenotypic parameters.

Five leaf phenotypic parameters, easy to measure, such as leaf length (from petiole to leaf apex), leaf width (average of phyllopodium width, the width of leaf middle and leaf apex), leaf thickness, petiole length and petiole diameter parameters had been measured by the digital display vernier caliper (accuracy 0.01mm).

2.3. Data analysis

In this study, the individuals of *L. communis* in each distance group was counted. The variation coefficient (CV) was used to represent the variation degree of each leaf trait. One-way ANOVA was used to compare the phenotypic variation of leaves in different groups.

3. Results and Analysis

3.1. Distribution pattern of *L. communis* population

483 individuals of *L. communis* were recorded (Table 2), and the trees (DBH ≥ 1cm) was 374 (77.43% of the total).

Table 2. The clint effect of *Lindera communis* distribution in Maolan National Nature Reserve, Guizhou, China

| No. of individuals | 0cm form clint | 0.1cm-10cm from clint | ≥10cm from clint |
|--------------------|----------------|-----------------------|-----------------|
| DBH ≥ 1cm          | 200            | 50                    | 124             |
| DBH<1cm, H ≥ 1.3m  | 10             | 19                    | 14              |
| H<1.3m             | 19             | 25                    | 22              |
Here was a certain correlation between the distribution of *L. communis* individuals and the distance from clint (Table 2). Among the individuals with trees (DBH ≥ 1cm), 53.48% in the 0cm group and followed by the ≥10cm group with 33.16%. Saplings (DBH<1cm, H ≥ 1.3m) and seedlings (H<1.3m) were distributed in the 0.1cm-10cm group (44.19% and 37.88%), followed by those in the ≥10cm group (31.82% and 33.33%). Although there were many arbor individuals in 0cm from clint group, it was not the best habitat for the establishment of seedlings and saplings. However, there were more seedlings, saplings and trees in the ≥ 10cm group from clint, which reflected that the species needed better habitats to the establishment.

The growth of *L. communis* individuals was affected by clint, too (Table 1). On the whole, the mean DBH of *L. communis* individuals was decreased with the increase of the distance between plant and clint. The coefficients of variation of *L. communis* individuals DBH in each distance group (Table 2), which indicated that the DBH distribution of this species was uncertain at different groups. By the individuals, the maximum DBH in this survey was 10.5cm in the group 0.1cm-10cm, which was 1.1cm and 2.4cm larger than the maximum in the 0cm group and ≥ 10cm group, respectively

3.2. Leaf phenotypic traits variation of *L. communis* with clint

The leaf phenotypic traits of *L. communis* in Maolan (Table 3) showed that the leaf length, width, width/length, thickness, petiole length and diameter were 79.71±12.95mm, 30.17±6.68mm, 0.38±0.07, 0.24±0.05mm, 6.65±1.87mm and 1.19±0.63mm, while the corresponding CVs were 16.25%, 22.15%, 17.42%, 20.72%, 28.08% and 52.75%, respectively. And the distances from *L. communis* to clint had significant effect on the leaf phenotypic traits.

However, there were significant differences in with different distances from clint (Table 3).

**Table 3.** The variations of leaf phenotypic traits in three groups of *Lindera communis* in Maolan

| Characters          | 0cm form clint | 0.1cm-10cm from clint | ≥ 10cm from clint |
|--------------------|----------------|-----------------------|------------------|
|                    | Max. (mm)      | Min. (mm)              | Mean (mm)        | CV (%) |
| LL                 | 114.34         | 28.00                  | 81.21            | 16.50  |
| LW                 | 49.05          | 3.00                   | 29.92            | 21.84  |
| LWL                | 0.61           | 0.07                   | 0.37             | 16.68  |
| LT                 | 0.45           | 0.14                   | 0.25             | 20.61  |
| PL                 | 11.86          | 1.25                   | 6.37             | 23.60  |
| PD                 | 1.66           | 0.10                   | 1.12             | 18.12  |

|                    | Max. (mm)      | Min. (mm)              | Mean (mm)        | CV (%) |
|--------------------|----------------|-----------------------|------------------|
| LL                 | 106.04         | 60.08                 | 77.39            | 13.07  |
| LW                 | 42.72          | 21.12                 | 29.49            | 14.49  |
| LWL                | 0.54           | 0.30                   | 0.38             | 12.86  |
| LT                 | 0.36           | 0.16                   | 0.24             | 18.15  |
| PL                 | 6.79           | 3.19                   | 4.50             | 31.39  |
| PD                 | 1.22           | 0.91                   | 1.45             | 12.47  |

Note: LL, leaf length. LW, leaf width. LWL, leaf width/length. LT, leaf thickness. PL, petiole length. PD, petiole diameter. Max., maximum. Min., minimum. CV, coefficient of variation.

The eigenvalues of leaf phenotypic traits were affected by the distance from clint, but it doesn't have a big change trend (Table 3). The maximum mean leaf length was in the 0cm group, followed by the ≥ 10 cm group. The mean value of leaf thickness was the largest in the 0cm group, followed by the 0.1cm-10cm group. The mean values of leaf width/length, petiole length and petiole diameter were the largest in the ≥ 10cm group, followed by the 0.1cm-10cm group. The mean value of leaf width was the largest in the ≥ 10cm group, followed by the 0cm group. By the One-way ANOVA test in the three groups, there were no significant differences in leaf width (P=0.1560), petiole diameter (P=0.0587) and petiole length (P=0.0782), but significant differences in leaf length (P=0.0314) and very significant differences in leaf thickness (P=0.0003) and leaf width/length (P<0.01).
The variation coefficient of *L. communis* leaf phenotypic traits varied with the distance group from clint (Table 3). The variation coefficients of leaf length, leaf width, leaf width/length, leaf thickness and petiole diameter were the largest in the ≥ 10cm group, while the smallest in the 0.1cm-10cm group. The coefficient of variation of petiole length was the largest in the 0.1cm-10cm group, and the smallest in the 0cm group. The coefficient of variation of petiole length increased first and then decreased with the distance from clint increasing. Meanwhile, the variation coefficients of leaf length, leaf width, leaf width/length, leaf thickness and petiole diameter decreased first and then increased with the increase of distance from clint.

4. Discussion

4.1. Effect of clint on the species distribution

Species distribution is affected by multiple factors such as topography, soil, light, human disturbance [24, 25], and physiological and ecological characteristics such as drought tolerance [26]. In karst areas, the heterogeneity of water and heat appears on multi-scale. On the mesoscale, the vertical zone distribution of plant from piedmont to mountain peak [27, 28] is a typical example, and on the microscale is the diversity of microhabitat that caused by the clint cutting the land surface [7, 29]. The microhabitat is an abiotic condition for the seed germination and sapling establishment. To survive, the roots of karst plants usually penetrate or climb cross the rocks, which are difficult to remove after disturbance [30-32], and then remain in the rocks. Once the disturbance is withdrawn, these residual roots or residual piles can sprout new plant individuals and quickly build up with the nutrients accumulated by the original residual. Although the trees from 0.1cm-10cm group was the minimum, but the maximum DBH tree appeared in this group (Table 2), and the individual is a sprouting stem. In the ≥ 10cm group, the number of individuals was the maximum but the mean DBH was the smallest, which might be due to the late establishment of seedlings and saplings. However, in the 0cm group, there were the most individuals and the largest mean DBH, but the individuals of seedlings and saplings were less, which reflected that the seedlings and saplings on exposed clint had a higher success rate, and its mechanism was worth further study.

4.2. Effect of clint on the leaf phenotypic

The degree of plant phenotypic variation is positively correlated with the degree of adaptation to different habitats [33]. The phenotypic plasticity of *L. communis* was little in this region because of its main CV < 30%. On the contrary, the plasticity of the petiole diameter of germinal trees was the highest (CV=52.75%, especially the variation coefficient of ≥ 10cm group reached 81.52%).

The clint can redistribute the soil water and fertilizer with the communities [7-10], the formed diversity microhabitat and affected the phenotypic plasticity of *L. communis*. The plasticity of leaf length, leaf width, leaf width/length, leaf thickness and petiole diameter was shown as ≥10cm group > 0cm group > 0.1cm-10cm from clint, indicating that habitat conditions of 0.1cm-10cm group were relatively stable.

5. Conclusion

In karst area, the clint played an important role in making microhabitat diversity by cutting the land surface. By analysed relationship of *L. communis* individuals distribution and leaf phenotypic traits variation with the clint, the study indicated that the clint had a profound influence effect on species distribution and adaption characteristics. Therefore, we can use the clint as a key node to protect and restore the plant population size.

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