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(Cryptocarya chinensis)

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Cryptocarya chinensis spatial distribution patterns caused by human disturbance in the lower subtropical monsoon evergreen broad-leaved forest

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Abstract: Lower subtropical monsoon evergreen broad-leaved forests are of high conservation significance in South China. Because of human activities, the forest has been largely destroyed; the remaining fragments are now mainly in several protected reserves. To further protect this forest outside the reserves and to study human influences on it, we analyzed the spatial pattern of *Cryptocarya chinensis*, a dominant tree in the forest near Changlong village, Guangzhou, China. Compared with low human disturbance forests, in which *C. chinensis* was clumped, we found that trees were randomly distributed, especially the young life stages. Human activities in this forest have also led to the decline of the *C. chinensis* seedling bank, suggesting that the population is regenerating badly.

Key words: spatial pattern; human disturbance; *Cryptocarya chinensis*; life stages; seedling bank

Today, a growing number of international agreements regarding biodiversity and sustainable development stress the importance of preserving typical ecosystems and habitats[1～3]. However, ecosystems do not consist simply of physical features. They include biological organisms interacting with the physical environment. Therefore, ecosystems can not be preserved without conservation of the biota.

Moreover, although establishing reserves that encompass representative examples of ecosystems is a good conservation strategy, reserves themselves can not be expected to preserve all the biodiversity. Because many organisms (e.g., birds and insects) move between different areas, it is unlikely that a few reserves will be able to sustain populations of all species. Therefore, it is important to preserve habitats outside reserves, even if they are small in area.

Lower subtropical monsoon evergreen broad-leaved forests are found in the tropical-subtropical transition zone in southern China (22—24°N), near the Tropical of Cancer. In contrast to similar latitudinal areas elsewhere, which are almost all dry or semidry lands, unique, luxuriant subtropical forests are well developed in southern China because of the areas proximity to the Pacific Ocean. Much of this forest ecosystem has already been destroyed. However, current overexploitation and the environmental deterioration that is accompanying economic development have made conditions even more serious. Recent inventories indicate that the forest has been reduced to a few isolated patches, which are currently protected because of their key role in the lower subtropical ecosystem. In addition, these forests support biotic diversity by providing food for birds, insects, and mammals[4].

Our knowledge of human influences on the lower subtropical monsoon evergreen broad-leaved forest is still incomplete[5]. Our objective here is to document changes brought about by human activities on the spatial pattern of *Cryptocarya chinensis* (Hance) Hemsl, a dominant tree in this forest.

Cryptocarya chinensis is a common evergreen tree widely distributed in lower subtropical southern China, growing up to 20 meters high. It is mesophyte, climax species in lower subtropical monsoon evergreen broad-leaved forest. *C. chinensis* is a half-shade tolerant species, high dense canopy will prevent its regeneration[6].

Human activities impose spatial patterning on forests that is often different from that of natural communities. For example, large-scale planting of economically important trees creates homogeneous landscapes, which may facilitate the spread of pests and pathogens[7]. Other human activities, such as the expansion of agriculture land and urban and infrastructure development, lead to forest fragmentation, which enhances environmental heterogeneity, isolates populations and reduces their size[8]. On a local scale, human-activities may indirectly affect the distribution of forest species by affecting the movements of pollinators, seed dispersers, and herbivores. For example, in Yellowstone National Park, wildlife management policies affected the movement, behavior and browsing patterns of elk which subsequently changed the distribution of aspen (*Populus tremuloides*)[9]. Such indirect influences may also occur through alteration of the physical conditions of forests, such as changes in soil characteristics[10] and fire frequency[11].

1 Materials and Methods

1.1 Site Description

The study site is near the village of Changlong (23°06′N, 113°18′E, 80 m a.s.l.), northeast of Guangzhou, Guangdong Province, China[12]. The mean annual temperature is 21.9℃, and the mean annual precipitation is 1738 mm, which falls mainly between April and October. The soil type is lateritic-red earth[12].

This forest was intensively logged twice in the 1940's and 1950's (Yu ZY, personal communication); then it was protected by the local people until about 1995[12]. However, in June 2003, the typical forest persisted in an area of only about 1 ha (Fig. 1). Newly cut stumps indicated frequent logging in the forest. Local people also raise chickens in the forest. Chickens kill tree seeds and seedlings by grazing and trampling. They also destroy the litter and surface layer of the soil, thereby preventing the germination and establishment of seedlings.

Because of human activities, the herbaceous stratum of this forest is typically sparse. Canopy trees in the forest are scattered and include *Castanopsis hystrix* DC., *Endospermum chinensis* Benth., *Engelhartia chrysolepis* Hance, *Cryptocarya concinna* Hance, *C. chinensis*, *Machilus chinensis* (Champ. Ex Benth.) Hemsl, and *Canthium dicoccum* (Gaertn.) Merr.

1.2 Data Collection and Spatial Statistics

All *C. chinensis* were mapped in a 50 m × 100 m plot in June 2003 (Fig. 1). Individuals were recorded for their diameter at breast height (*dbh*) and height. Individuals < 2.5 cm *dbh* were only recorded for height. Trees were classified into life stages following Wang *et al*[6]. Some previously cut trees had re-sprouted from their stumps or stems. Because their age could not be determined, these trees were not included in the life stage classification.

Because of human activities, the study plot was very heterogeneous. *Cryptocarya chinensis* were densest on the lower slope

（Fig 1）. To analyze the spatial pattern, smaller homogeneous subplots were defined using local density[13]. Local density in circles of radius 12. 5 m was determined at each node of a 10 m × 10 m systematic grid. The lowess method (local weighted scatterplot smoothing) was then used to predict the values of the local density function at each node of a 10 m × 10 m systematic grid. The local regression was computed over the eight nearest neighbors to minimize the mean smoothing error. Then, two approximately homogeneous subplots were delineated by interpolation of the predicted values（Fig 1）.

Ripley's L（t）-function analysis was used to characterize the spatial patterns of C. chinensis in each of the homogeneous subplots[6]. Briefly, when L（t）= 0, the spatial pattern is random at the scale of t; when L（t）< 0, the distribution is uniform; and when L（t）> 0 the distribution is clumped. The significance of the observed patterns was tested（against the null hypothesis of Poisson dispersion）by randomization tests with 10, 000 simulations. All calculations and the contour lines were performed with ADE-4[14]. Spatial analyses were not conducted for Life Stages Ⅳ and Ⅴ because there were too few individuals.

2 Results and Discussion

The spatial distribution of the different C. chinensis life stages are presented in Fig. 2. Ripley's L（t）analysis indicated that C. chinensis were randomly distributed at large distances, but significantly clustered at small and intermediate distances, except for Life Stage Ⅰ. The spatial pattern for Life Stage Ⅰ tended to be random, except at the largest distance. These random patterns（especially for young life stages）were in contrast to what we found in studies of low human disturbance forests, in which all life stages were clustered at almost all distances[6].

Accoding to Cai et al[12], this forest was still well protected ten years ago. But since then, its condition has changed greatly. The impact of humans on C. chinensis can be seen in many ways

First, the forest is easily accessed from the village and it has frequently been subject to human disturbances like logging. Although the number of C. chinensis trees that have been logged cannot be determined, tree re-sprouts were about 25% the total individuals, but fewer than one-third of cut trees were in Life Stage Ⅳ and Ⅴ（a size suitable for firewood or building）. However, as a previous study reported[12] and from other records（Yu ZY, personal communication）, the absence of large trees may be caused by intensive logging in the past. Presently only five large trees（Life stage Ⅴ）remained, two within the study plot, and three outside it（Fig 1）.

Second, the influence of human activities on the life stage distribution can be seen in the absence of younger life stages （Fig 1）. Previously, there was a 1200 m² study plot in this forest[12], in which a 100 m² subplot was used to investigate young C. chinensis with heights between 0. 5 m and 1. 5 m. Although the subplot was small, there were 13 C. chinensis individuals of this size in the subplot. If demographic trends had continued, we would have expected approximately 650 individuals with such heights in our plot. However, the total number of individuals（cut and uncut）of C. chinensis in our plot is 288. If we reduce our study area to the size of the previous study area（1200 m²）, the density of all individuals is seven individuals／100 m², and four individuals／100 m² with heights between 0. 5 m and 1. 5 m. This is considerably fewer than found in the previous study.

Although no C. chinensis seedlings were found in the previous study[12], the study area was small （four 1 m × 1 m subplots within the 1200 m² area）. We found only 12 seedlings（Life Stage Ⅰ）in our plot, and they were concentrated in the

● Life stage Ⅴ (adults 7.5cm ≤ dbh, 2 individuals)
⊛ Life stage Ⅳ (juveniles, 2.5cm ≤ dbh < 7.5, 3 individuals)
◇ Life stage Ⅲ (older saplings, 1m ≤ height, 95 individuals)
△ Life stage Ⅱ (younger saplings, 0.33m ≤ height < 1, 105 individuals)
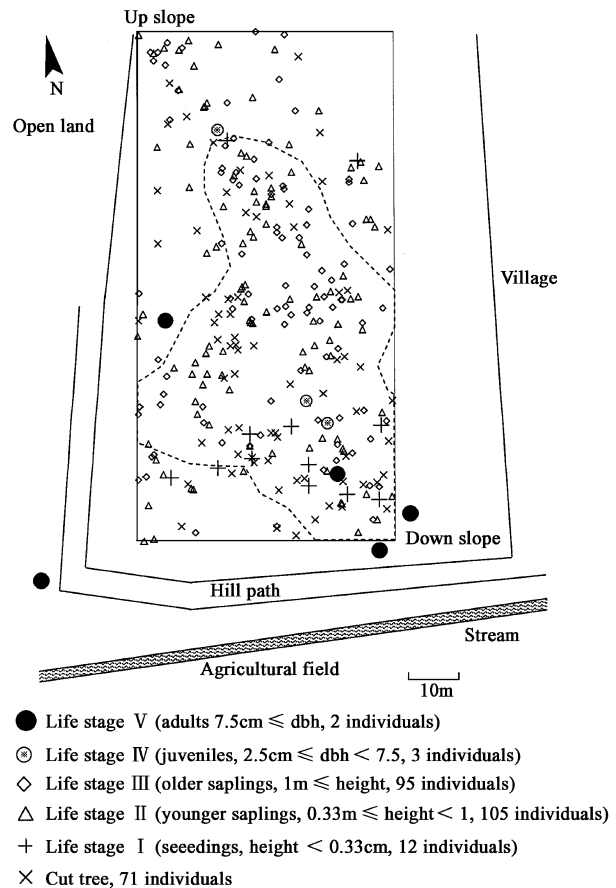+ Life stage Ⅰ (seeedings, height < 0.33cm, 12 individuals)
× Cut tree, 71 individuals

Fig 1 Map of Cryptocarya chinensis in a 50m × 100m plot of lower subtropical evergreen broad-leaved forest near the village of Changlong, Guangzhou, Guangdong Province, China. Two smaller subplots are divided by the dotted lines

lower-slope of the plot, without any positive association with other life stages (Fig 1). As in other forests[15], the seedling bank is important for forest regeneration[16]. In the future, the fraction of seedlings that enter the sapling stage is unknown. Given the isolation of this forest and human activities within it, we suspect that the seedling bank will disappear within few years
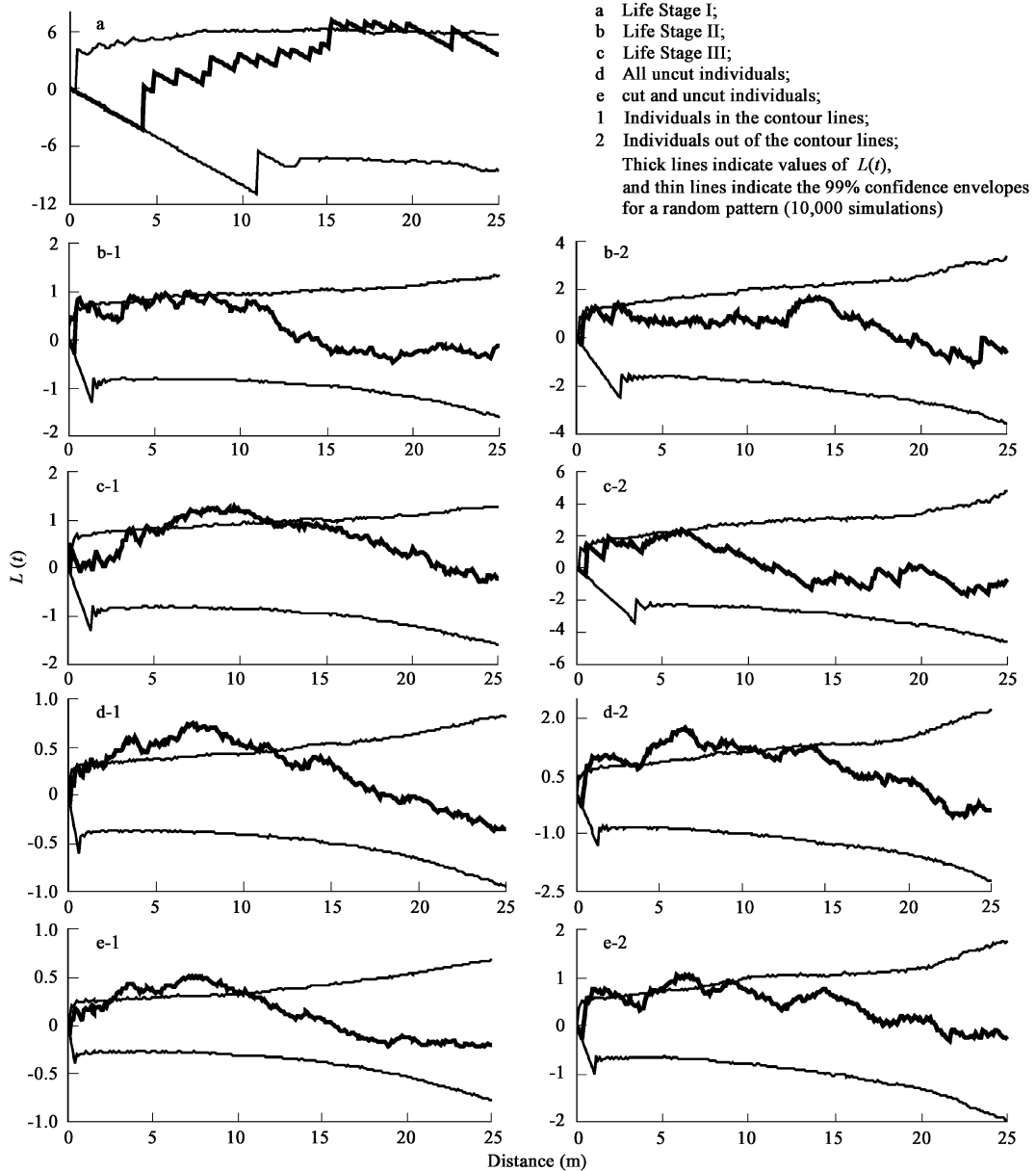

a   Life Stage I;
b   Life Stage II;
c   Life Stage III;
d   All uncut individuals;
e   cut and uncut individuals;
1   Individuals in the contour lines;
2   Individuals out of the contour lines;
    Thick lines indicate values of $L(t)$,
    and thin lines indicate the 99% confidence envelopes
    for a random pattern (10,000 simulations)

Fig 2   Ripley's L-function analysis of the spatial pattern of *Cryptocarya chinensis*

Third, for isolated trees, their seedlings should be concentrated either around or away their parent trees depending on the level of seed predation, as suggested by a species (*Cryptocarya alba*) in the same genus[17]. In our previous study we found that *C. chinensis* seedlings were clumped but independently associated with adult trees in a low human disturbance forest, suggesting that a suitable microhabitat was required for seedling establishment[6]. However, this is not the case for present study. Seedlings were randomly distribution in small patches (Fig 1, Fig 2a), indicating restricted regeneration, but confirming that a suitable microhabitat is required for seedling establishment[6]. In forests with low human impacts, seedlings establish better in microhabitats with a litter layer and/or on soft soil, both of which have been severely disturbed by chickens in our study area. However, intensive logging in our study area increases canopy gaps, which should be advantageous for

seedling survival[6]. The low regeneration we observed and its random distribution may also be caused by low seed production by the few adult trees or by inbreeding depression of seeds or seedlings in this small population[18—20]. Overall, our results indicate that human-induced spatial patterns of *C. chinensis* in our study area differ considerably from that in more natural forests. In sites with low human disturbance, *C. chinensis* life stages were clustered, whereas we found a near random distribution of trees, and regeneration is declining. Even if restoration of this forest is successful, its floristic composition will probably never be identical to the previous forest.

We do not know what compensation will be required to convince local people to protect this forest. More importantly, laws and policies governing natural resources are still not sufficient to tackle the scale of the conservation problems. The government should design a more effective conservation strategy involving local people to protect and manage forest biodiversity. In addition, further research into the population genetics, dispersal, pollination, seed bank, regeneration, and habitat requirements of *C. chinensis* will be needed to fully understand the spatial distribution of this species, and the protection of the forest.

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