



Original Research Article

doi: <https://doi.org/10.20546/ijcrbp.2018.507.001>

Study on the Population Structure and Community Characteristics of *Phoebe* Nees and *Machilus* Nees Plants in Zigui Country, Hubei Province, China

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Article Info

Date of Acceptance:
19 June 2018

Date of Publication:
06 July 2018

Keywords

Community characteristics
Machilus species
Phoebe species
Plant population
Zigui Country

ABSTRACT

In order to provide better references for the protection and development of *Phoebe* and *Machilus* plants germplasm resources, community ecology method was used to investigate the *Phoebe* and *Machilus* community in Zigui Country, Hubei Province. The distribution of the species, the number of resources and the habitat conditions were recorded, the community characteristics and the impact of different factors on the *Phoebe* and *Machilus* community were analyzed, and the correlation rules between the *Phoebe* and *Machilus* community and the living environment were revealed. The results showed that the populations of *P. chinensis* and *Machilus pauhoi* were significantly more than those of *P. zhennan* and *M. ichangensis*, the community structure was more complete and the potential for development was better. The flora composition of *Phoebe* and *Machilus* community in Zigui Country was relatively complex, its flora was diverse and abundant, its dominant population was prominent, and the genera of its families were relatively dispersed with some natural regeneration ability. *Phoebe* and *Machilus* distribution from the point of view, when the slope was 20°, *Phoebe* and *Machilus* distribution was the most ideal slope. In the survey area, the predominance was of angiosperms, especially dicotyledons. The ferns and gymnosperms were relatively poor.

Introduction

Phoebe and *Machilus* is a peculiarly precious species in China (Ding et al., 2015), which includes *Phoebe* Nees and *Machilus* Nees plants and some related species. There are about 94 species of

Phoebe in the world. There are 34 species and 4 varieties in China, mainly distributed in the south of the Yangtze River (Liu et al., 2011). There are about 100 species of *Machilus* in the world, mainly distributed in Southeastern Asia and subtropical areas. Flora of China editorial board (1982)

reported that there are about 68 species and 3 varieties in our country, distributed in the South West and South areas.

Phoebe and *Machilus* are famous for their excellent material quality, because of their tall and beautiful tree shape, evergreen, beautiful branches. *Phoebe* and *Machilus* not only is a good ornamental tree species, but also has the functions of noise reduction, dust retention, air purification, etc. They are excellent tree species with economic value, ornamental value and ecological value (Ma et al., 2017; He et al., 2017). However, because of its great practical value, *Phoebe* and *Machilus* are cut down in the middle of the 20th century. The number of populations decreased sharply, the community patches were reduced, and the habitat was destroyed, making the *Phoebe* and *Machilus* less and less, especially wild resources, which is currently in an endangered state (Jia et al., 2014; Xu, 2016; Yu et al., 2017).

This paper carried out a survey of the *Phoebe* and *Machilus* resources in Zigui Country, Hubei Province, aiming to review the achievements made by the *Phoebe* and *Machilus*. Institute and discuss the problems existing in the production, so as to lay the foundation for the further protection and development of the *Phoebe* and *Machilus* resources and the reasons for the endangerment of the *Phoebe* and *Machilus*. Put forward scientific and reasonable conservation measures.

The physical and geographical environment in Zigui Country

Zigui Country is located at the bank of the Xiling Gorge in the western Hubei Province. It spans 110° 0'4" to 110° 18'41" east longitude, 30° 38'14" - 31° 11'31" north latitude, and the maximum horizontal distance is 66.1km. The maximum vertical distance between the north and the south is 60.6km. The total area is 2427km², accounting for 1.31% of the total area of the province, accounting for 11.51% of the total area of the city. The terrain is high in the southwest and low in the northeast. The mountains in the territory are the Daba Mountains and Wushan

Mountains. The topography is undulating and the mountains are stacked. The county has an average elevation of 1048m.

Zigui Country is located in the middle latitudes and is subtropical continental monsoon climate. With four distinct seasons, abundant rainfall, abundant sunshine, and mild climate, affected by the topography and altitude difference, the vertical change of climate types is obvious. The average annual frost-free period is 301 days, the average annual snowfall is 3.9 days, and the average annual precipitation is 1006.8mm. The county's annual average photoperiod is 1619.6 hours. Summer is less winter and moderate in spring and autumn; air relative humidity is 72%. The annual average temperature is 17.9°C, the extreme minimum temperature is -8.9°C, and the extreme maximum temperature is 42°C.

The soil types of the county mainly include 7 types of soil types, yellow soil, yellow brown soil, brown soil, lime soil, purple soil, fluvo-aquic soil, and paddy soil. Zigui Country vegetation resources are relatively abundant. According to statistics, there are about 80 families, 190 genera, and nearly 800 species of trees and bushes in the county. The forest structure is diverse. The plant community includes 6 major species, 12 sub-categories, and 5 flora.

Through consulting data and field surveys to understand the situation of the native *Phoebe* and *Machilus*, a comprehensive survey was conducted on the Maoping and Jiuwanxi, two townships with relatively concentrated distribution.

Materials and methods

Research methods

For *Phoebe* and *Machilus* survey in Zigui Country, Hubei Province, a sample method was used for investigation (Zhou et al., 1993; Wang et al., 1995). We choose a representative lot setting master sample in the community. A sample plot was selected for each of Maoping and Jiuwanxi, and 20×20m standard plots were set for each plot.

In each sample plot, the “Each Wood Logging Survey Method” was adopted to investigate all the *Phoebe* and *Machilus* communities and their surrounding habitats, including the tree height, diameter at breast height, ground diameter, crown width and health status of each tree, the geographical coordinates, elevation, slope direction, slope, slope position, canopy density, cover degree, soil type, soil pH, habitat of the sample plot, Human disturbance patterns, intensity, dominant species and associated species

in the surrounding tree layers, shrub layers, and herbaceous layers (Wu et al., 2017; Yuan et al., 2017).

Data analysis

The vital value of species is an important index in the calculation and assessment of species diversity. The comprehensive importance of plant species in the community is expressed by the integrated numerical formula:

The importance value of the tree (I) = [relative density (D) + relative frequency (F) + relative saliency (T)] / 3

The important value of shrub species or herb (I) = [relative density (D) + relative frequency (F) + relative coverage (C)] / 3

The relative density, relative frequency, relative saliency, and relative coverage are calculated as follows:

Relative density (D) = (number of a species / total number of all species) × 100%

Relative frequency (F) = (frequency of one species / total frequency of all species) × 100%

Relative saliency (T) = (cross-sectional area of a species / total cross-sectional area of all species) × 100%

Relative coverage (C) = (The sum of cover of a species / The sum of all seed coverage) × 100%

Results

Population characteristics

Phoebe Nees and *Machilus* Nees plants resources in Zigui Country

Based on the investigation of the resources of *Phoebe* and *Machilus* in Zigui Country, Hubei Province, there are two species of *Phoebe*:

P. zhennan and *P. chinensis*; 2 species of *Machilus*: *M. pauhoi* and *M. ichangensis*. Among them, there are 58 plants belonging to the *Phoebe* and *Machilus*, 7 plants of *P. zhennan*, accounting for 12.07% of the total; 13 plants of *P. chinensis*, accounting for 22.41% of the total; 31 plants of *M. pauhoi*, accounting for 53.45% of the total; 7 trees of *M. ichangensis*, accounting for 12.07% of the total number. This shows that *M. pauhoi* is the dominant tree species in this area.

Table 1. *Phoebe* and *Machilus* plants resources in Zigui Country.

Sl. No.	Plant name	Quantity	Proportion (%)
1	<i>Phoebe zhennan</i>	7	12.07
2	<i>Phoebe chinensis</i>	13	22.41
3	<i>Machilus pauhoi</i>	31	53.45
4	<i>Machilus ichangensis</i>	7	12.07

The relationship between the distribution and orientation of *Phoebe* and *Machilus* population

According to the statistics of *Phoebe* and *Machilus* in different slope orientations and different community levels, in the sunny slope environment, *Phoebe* and *Machilus* was distributed in a very rare number, with only one

succession layer of *Phoebe* and *Machilus*; in the condition of shady slopes, *Phoebe* and *Machilus* individuals accounted for 98.3% of the total number, and there was no updated layer of *Phoebe* and *Machilus*, and the average DBH of the main forest layer is 5.0563cm more than that of the successional layer, and the average tree height difference is 3.3377m.

Table 2. Distribution of *Phoebe* and *Machilus* populations in different aspects.

Aspect	Community level	No. of plants	Mean DBH /cm	Average tree height /m
Shady slope	Update layer	0	0.00	0.00
	Succession layer	27	4.67	3.56
	Main forest layer	30	9.73	6.89
Sunny slope	Update layer	0	0.00	0.00
	Succession layer	1	4.00	2.50
	Main forest layer	0	0.00	0.00

Relationship between population distribution and slope

The statistical results of the survey plots: from the number distribution of *Phoebe* and *Machilus*, at a slope of 20°, *Phoebe* and *Machilus* individuals account for 94.8% of the total; When the slope is 33°,

it accounts for 5.2% of the total. From the perspective of community level, when the slope is 20° and the slope is 33°, the number average diameter at breast height, and mean tree height in the main forest layer were greater than those in the succession layer, and there were no renewal layers, indicating that the community showed a decline type.

Table 3. Distribution of *Phoebe* and *Machilus* populations in different slopes.

Slope	Community level	No. of plants	Mean DBH /cm	Average tree height /m
20°	Update layer	0	0.00	0.00
	Succession layer	27	4.67	3.56
	Main forest layer	28	9.56	6.84
33°	Update layer	0	0.00	0.00
	Succession layer	1	4.00	2.50
	Main forest layer	2	12.05	7.65

Community characteristics: Community species composition

Through the field survey of plots, there are 49 species of *Phoebe* and *Machilus* in Zigui Country, belonging to 32 genera and 44 genera. There are 1 family and 1 genera in 1 family of fern; 1 family and 1 genera in 1 family of gymnosperms; 47

families, 43 families and 29 families of angiosperms. Among them, dicotyledonous plants were the most, accounting for 80.64%, 84.09%, and 83.67% of the total families, total genera and total species respectively. In the survey area, the predominance was recorded for angiosperms, especially dicotyledons. The ferns and gymnosperms were relatively poor.

Table 4. *Phoebe* and *Machilus* species statistics in Zigui Country.

Type	Family	Genus	Species
Ferns	1	1	1
Gymnosperms	1	1	1
Monocotyledonous plants	4	6	6
Dicotyledonous plant	25	37	41
Total	31	45	49

The important value

The important values of *M. pauhoi*, *Alangium platanifolium* and *Iris tectorum* in *Phoebe* and *Machilus* species in Zigui Country were the

highest. There are 4 important values in the tree layer plants exceeding 1%, and the difference between the maximum value and the minimum value is 2.85%. Among the shrub layer plants, there are 3 important values exceeding 1%, and the difference

between the maximum value and the minimum value is 1.65%. There are 4 important values in the vegetation layer plants exceeding 1%, and the difference between the maximum value and the minimum value is 3.45%. From this we can see that the dominant tree species is *M. pauhoi*; the dominant species in the shrub layer is *A. platanifolium*; and the

dominant species in the grass layer is *I. tectorum*. In addition to the dominant species of *Phoebe* and *Machilus* species, there are many other companion species around, with rich plant composition, prominent dominant populations, and pedigree structures that are decentralized and have a certain ability of natural regeneration.

Table 5. Important value of tree layer plant.

Plant name	Relative frequency (%)	Relative density (%)	Relative saliency (%)	Important value (%)
<i>M. pauhoi</i>	2.68	4.55	1.82	3.02
<i>Carya cathayensis</i>	1.34	2.46	1.52	1.77
<i>Cyclobalanopsis glauca</i>	1.12	1.58	1.27	1.32
<i>Liquidambar formosana</i>	1.34	0.95	0.91	1.07
<i>Phoebe chinensis</i>	0.94	0.67	0.88	0.83
<i>Pinus massoniana</i>	0.89	0.48	0.30	0.56
<i>Sapium sebiferum</i>	0.67	0.40	0.55	0.54
<i>M. ichangensis</i>	0.67	0.40	0.42	0.50
<i>Cinnamomum longepaniculatum</i>	0.47	0.49	0.51	0.49
<i>Phoebe zhennan</i>	0.45	0.48	0.52	0.48
<i>Juglans cathayensis</i>	0.67	0.40	0.36	0.48
<i>Paulownia fortunei</i>	0.41	0.52	0.45	0.46
<i>Broussonetia papyrifera</i>	0.45	0.51	0.31	0.42
<i>Swida wilsoniana</i>	0.39	0.36	0.38	0.38
<i>Illicium verum</i>	0.33	0.43	0.36	0.37
<i>Firmiana platanifolia</i>	0.37	0.35	0.39	0.37
<i>Mallotus japonicus</i>	0.31	0.43	0.26	0.33
<i>Toxicodendron succedaneum</i>	0.32	0.29	0.34	0.32
<i>Ligustrum lucidum</i>	0.22	0.32	0.24	0.26
<i>Hypericum monogynum</i>	0.26	0.15	0.29	0.23
<i>Platycarya strobilacea</i>	0.32	0.08	0.12	0.17

Table 6. Important value of shrub layer plant.

Plant name	Relative frequency (%)	Relative density (%)	Relative coverage (%)	Important value (%)
<i>A. platanifolium</i>	2.34	1.98	1.15	1.82
<i>Ligustrum quihoui</i>	1.34	1.46	1.52	1.44
<i>Schisandra chinensis</i>	1.12	1.19	1.53	1.28
<i>Alchornea davidii</i>	0.45	0.71	1.34	0.83
<i>Debregeasia orientalis</i>	0.38	0.79	0.85	0.67
<i>Boehmeria tricuspis</i>	0.67	0.55	0.71	0.64
<i>Smilax china</i>	0.45	0.40	0.55	0.47
<i>Ilex chinensis</i>	0.43	0.24	0.56	0.41
<i>Lindera glauca</i>	0.46	0.32	0.44	0.41
<i>Sambucus williamsii</i>	0.48	0.24	0.42	0.38
<i>Mahonia fortunei</i>	0.47	0.26	0.31	0.35
<i>Elaeagnus lanceolata</i>	0.39	0.23	0.34	0.32
<i>Rubus lambertianus</i>	0.45	0.16	0.24	0.28
<i>Viburnum dilatatum</i>	0.22	0.08	0.21	0.17

Table 7. Important value of grassland plant.

Plant name	Relative frequency (%)	Relative density (%)	Relative coverage (%)	Important value (%)
<i>Iris tectorum</i>	2.21	3.86	4.83	3.63
<i>Pilea notata</i>	1.41	3.28	2.63	2.44
<i>Hemerocallis fulva</i>	1.16	1.12	1.14	1.14
<i>Trachelospermum jasminoides</i>	1.12	0.93	1.05	1.03
<i>Gonostegia hirta</i>	0.72	1.08	0.93	0.91
<i>Setaria palmifolia</i>	0.91	0.75	1.02	0.89
<i>Pteris vittata</i>	0.93	0.81	0.75	0.83
<i>Hedera nepalensis</i>	0.71	0.36	0.79	0.62
<i>Euphorbia humifusa</i>	0.74	0.31	0.51	0.52
<i>Plantago depressa</i>	0.47	0.39	0.25	0.37
<i>Eriophorum comosum</i>	0.47	0.22	0.24	0.31
<i>Viola grypoceras</i>	0.25	0.36	0.22	0.28
<i>Arthraxon hispidus</i>	0.23	0.27	0.27	0.26
<i>Euphorbia helioscopia</i>	0.21	0.16	0.18	0.18

Discussion and conclusions

At present, researches on populations and communities of *Phoebe* and *Machilus* genus are reported in China, with *P. bournei*, *P. chekiangensis* and *P. hui* being more common. Studies on *Phoebe* and *Machilus* natural community related issues are still rare and mostly concentrated on natural *Phoebe* and *Machilus* physiology, biochemistry, plantation, and phenotypic diversity of natural populations (Hu et al., 2010; Li et al., 2008; Ma et al., 1989), there are few studies on the composition and structure of *Phoebe* and *Machilus* population and its relationship with major ecological factors. This study conducted a field survey of the *Phoebe* and *Machilus* population in Zigui Country, Hubei Province, and a preliminary study of the characteristics of population characteristics, *Phoebe* and *Machilus* community characteristics, and links with major ecological factors, etc. It provides a theoretical basis for the protection, renewal and sustainable development of its population.

In the quantity of *Phoebe* and *Machilus*, the number of *P. chinensis* and *M. pauhoi* was significantly higher than that of *P. zhenna* and *M. ichangensis*. The community structure was more complete and the development potential was better. From the point of view of the distribution of *Phoebe* and

Machilus, the optimum slope of *Phoebe* and *Machilus* is the slope of 20°. From the perspective of community level, the number of *Phoebe* and *Machilus* trees, average diameter at breast height, and mean tree height in the main forest layer were greater than those in the succession layer, and there were no renewal layers. In the survey area, the predominance of angiosperms, especially dicotyledons. The ferns and gymnosperms were relatively poor. From the perspective of the basic composition of *Phoebe* and *Machilus* species in the plant genera, the *Phoebe* and *Machilus* community in Zigui Country has more complex plant components and diverse plant composition. From the important values of the *Phoebe* and *Machilus* species, it can be seen that besides the dominant species, there are many other companion species around, with rich plant composition, prominent dominant populations, and pedigree structures that are decentralized, and there is a certain amount of natural renewability.

In order to effectively protect wild *Phoebe* and *Machilus* resources, according to the status quo of *Phoebe* and *Machilus* resources in Zigui Country, we propose the following measures:

- (1) To form an effective wild plant resource protection system to protect *Phoebe* and *Machilus* resources on the spot. In addition,

efforts should be made to intensify the investigation and protection of various wild animal and plant resources so as to fully and reasonably perform protection work.

- (2) Protecting protected area. Most of the *Phoebe* and *Machilus* resources in Zigui Country are located in the Jiuwanxi and the Three Gorges Bamboo Sea Area. The scope of protection of these two scenic spots can be specifically expanded to facilitate the conservation and management of wild *Phoebe* and *Machilus* resources and continuously improve the management level of the protected areas by improving the theoretical knowledge of managers. For the *Phoebe* and *Machilus* species that appear in the scenic spot, it is necessary to be listed after expert appraisal, which is conducive to the standardization of the management and protection of wild *Phoebe* and *Machilus* sapwood resources. It is also conducive to the improvement of the popularity of Zigui Country.
- (3) Strong development and utilization are the best protection. Zigui Country Forestry Scientific Research Department can actively carry out research work on *Phoebe* and *Machilus*. At the same time, we must also actively cooperate with major scientific research institutions to conduct in-depth research on the rapid propagation techniques, afforestation and afforestation techniques of *Phoebe* and *Machilus*, and popularize and promote the application of *Phoebe* and *Machilus* in landscaping and landscape design. This will give Zigui Country advantages in resources and scientific research. Together, we will jointly promote the development of the *Phoebe* and *Machilus* comprehensive utilization industry.

Conflict of interest statement

Authors declare that they have no conflict of interest.

Acknowledgement

This work was supported by the national second survey for key protected wild plant resources (special investigation for *Phoebe* and *Machilus* in Hubei Province), the Science and Technology Support Program in Hubei Province of P. R. China (2013BBB24), the Natural Science Foundation Project in Hubei Province of P. R. China (2017CFB390).

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How to cite this article:

He, X., Sun, B., Huang, C., Zhu, S., Hu, D., 2018. Study on the population structure and community characteristics of *Phoebe* Nees and *Machilus* Nees plants in Zigui Country, Hubei Province, China. Int. J. Curr. Res. Biosci. Plant Biol. 5(7), 1-8. doi: <https://doi.org/10.20546/ijcrbp.2018.507.001>