

Given this context, the present review aims to synthesize current knowledge on the variation in secondary metabolite traits of *L. japonicus* and explore their functional implications in gynecological applications. It focuses on the relationship between metabolic diversity and pharmacological efficacy, as well as the underlying genetic and environmental determinants. By integrating ethnobotanical knowledge with modern molecular research, this study seeks to provide a comprehensive framework for the standardized utilization and future development of *L. japonicus*.

2 Botanical Characteristics and Resource Distribution of *Leonurus japonicus*

2.1 Taxonomic status and morphological characteristics

Leonurus japonicus Houtt. is an herbaceous species in the family Lamiaceae, subfamily Lamioideae, and belongs to the small genus *Leonurus*, which comprises roughly 25 species distributed mainly across temperate to tropical Eurasia (Oak et al., 2021). Within the genus, *L. japonicus* is closely related to other medicinal taxa such as *L. cardiaca* and *L. sibiricus*, but differs in both chromosome number ($2n = 20$) and characteristic accumulation of leonurine, features that support its taxonomic separation and pharmacological distinctiveness (Yang et al., 2022). Floral and pollen micromorphology studies show that *L. japonicus* shares the typical Lamiaceae traits of zygomorphic, bilabiate corollas and bi-reticulate pollen exine, reinforcing its placement in Leonureae while also providing diagnostic features to distinguish it from congeners.

Morphologically, *L. japonicus* is an annual or biennial herb reaching up to 1-1.5 m, with square stems, opposite leaves, and verticillaster inflorescences typical of Lamiaceae (Rojas-Sandoval and Acevedo-Rodríguez, 2022). Leaves are palmately lobed and serrate, while the purple to pink bilabiate flowers bear abundant glandular and non-glandular trichomes that contribute to both defense and secretion of aromatic and medicinal compounds. In China, the plant flowers mainly from June to September and fruits from September to October, though in tropical regions it can flower throughout the year, reflecting notable phenological plasticity (Figure 1) (Huang et al., 2020).

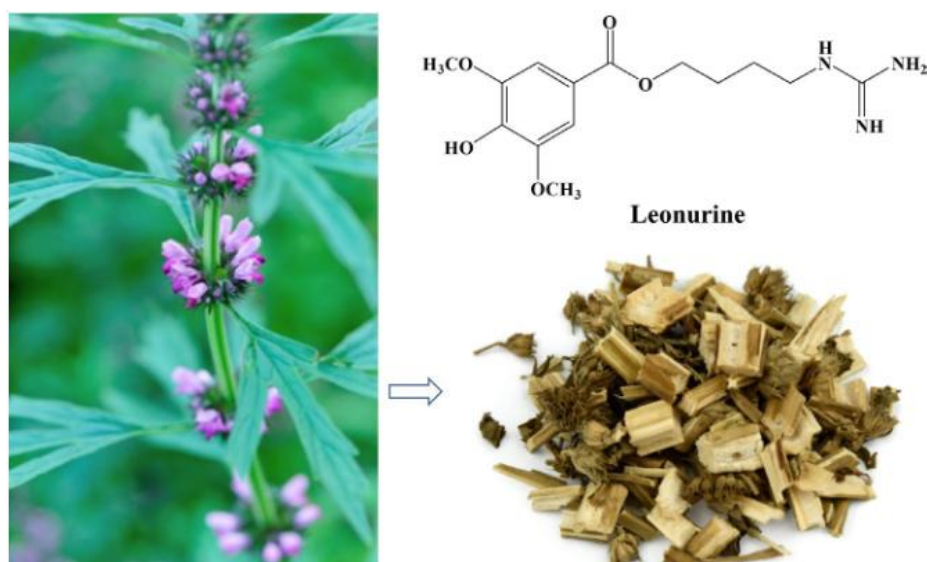


Figure 1 The photograph of *Leonurus japonicus* Houtt. and the structure of leonurine (Adopted from Huang et al., 2020)

2.2 Geographic distribution and ecological adaptability

Leonurus japonicus is native to East Asia but now shows a nearly cosmopolitan distribution, occurring in temperate and tropical regions of Asia, parts of Europe, and the Americas as an introduced or naturalized species (Hu et al., 2025). Within China, it is widely distributed from lowlands to montane areas, supporting its long history of use and large domestic demand as a medicinal resource. Habitat-suitability modeling indicates that its global and national centers of occurrence are concentrated in Southeast Asia, southern and eastern China, and extended regions such as South America and the Gulf of Mexico, underscoring its strong capacity for range expansion (Chen et al., 2024a).