

Investigating the status of *Cinnamomum chago* (Lauraceae), a plant species with an extremely small population endemic to Yunnan, China

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Abstract *Cinnamomum chago* is a woody species of the family Lauraceae endemic to Yunnan province, China, previously known from only one location, and categorized as a Plant Species with Extremely Small Population. We surveyed to determine the distribution and population size of *C. chago*, characterize its habitat, identify any threats, assess its conservation status, and provide guidelines for its management and conservation. During 2014–2017 we found only 64 mature *C. chago*, in five locations. These small, fragmented populations occur along Lancang River in Dali Prefecture at altitudes of 2,200–2,400 m. The species' extent of occurrence is c. 923 km², with an area of occupancy of c. 60 km². The habitat of the species has been degraded by expansion of pastoral activities and deforestation. We recommend categorization of *C. chago* as Endangered on the IUCN Red List, prevention of the collection of seeds and wood of the species, protection and monitoring, and ex situ propagation for future reintroductions.

Keywords China, *Cinnamomum chago*, conservation status, conservation strategy, endemic plant, extremely small population, habitat

China is a high priority for biodiversity conservation, with > 30,000 vascular plant species, of which c. 10,000 are endemics (Yang et al., 2005; Volis, 2016). In Yunnan province 1,010 stenochoric endemic seed plants have been recorded (Wu et al., 2011; Liu & Peng, 2016). Species of the family Lauraceae have significant ecological and economic value (Ravindran et al., 2003; Huang et al., 2016; Zhang et al., 2018), with a total of 445 species (316 endemic) recorded in China, of which 109 are categorized as Endangered on the China Species Red List (Wang & Xie, 2004; Yang & Liu, 2015). The Lauraceae species *Cinnamomum chago* was first found in La-Guo village, Yunnan province, in 1988 (Sun & Zhao, 1991), where it is a resource for timber and edible nuts (Plate 1). Its morphological features (opposite leaves,

pinnate leaf veins, naked bud and no glandular fossa) and phylogenetic analysis indicate that it is a key species in the phylogeny and evolution of *Cinnamomum* (Plate 2; Dong et al., 2016; Huang et al., 2016).

Lack of information on the distribution and status of a threatened endemic species can impede its conservation (Fenu et al., 2011; Wang et al., 2016; Laguardia et al., 2017). Previously, *C. chago* was known only from La-Guo village, at c. 2,300 m altitude (Sun & Zhao, 1991). It is listed as one of the 321 Plant Species with Extremely Small Populations in south-west China that require comprehensive surveys and germplasm conservation (Yang & Sun, 2017). As it had been suggested that *C. chago* could occur in other areas of Yunnan (Dong et al., 2016), we surveyed to characterize its distribution and habitat, identify any threats, assess its conservation status using the Red List categories and criteria (IUCN, 2012, 2017; Hoffman et al., 2008; Fenu et al., 2011), and provide guidelines for its management and conservation.

We firstly noted the characteristics of the specimens of *C. chago* deposited in the herbarium of Yunnan University, and verified the historical collection site in La-Guo village. We compiled information on *C. chago* from the literature and from experts, to identify sites where the species could potentially occur. At each potential site we showed photographs of the herbarium specimens and described the species' characteristics to local villagers and foresters. We received information regarding eight potential sites in Dali Prefecture, which we surveyed during the flowering (April–May) and fruiting seasons (September–October) of 2014–2017, noting the locations of any *C. chago* with a GPS, and the number of mature individuals, altitude and habitat type. The extent of occurrence and area of occupancy (IUCN, 2012, 2017), the latter using a 4 km² grid, were determined with ArcGIS 10.3 (Esri, Redlands, USA).

We found 64 mature *C. chago* in five locations, in 120 days of surveys (Table 1). All populations, except that at La-Guo, are new discoveries (Fig. 1). The five populations occur in the mountains along Lancang River in Dali Prefecture, at altitudes of 2,200–2,400 m. The total extent of occurrence is 923.23 km² and the area of occupancy is 60.19 km² (Table 1). The greatest distance between populations is 82.05 km, between Da-Shi-Ba and Xin-Cun, and the shortest distance (< 1 km) is between Shun-Bi-Xiang and Xin-Cun (Fig. 1).

Habitat quality is important for the long-term persistence and survival of threatened plant species (Shen et al.,

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PLATE 1 Furniture made from the wood of *C. chago* (a), seeds traded in an agricultural market (b), and felled individuals (c & d).

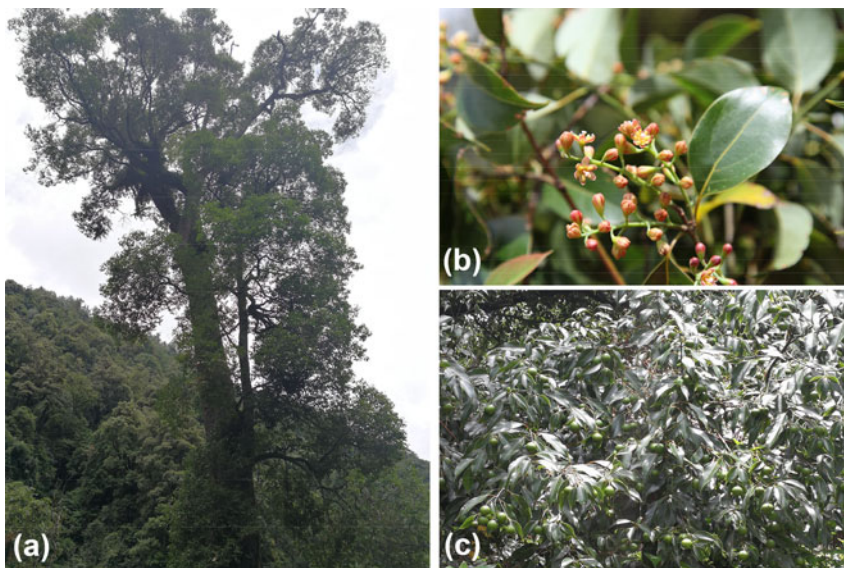


PLATE 2 *Cinnamomum chago* (a), and its flowers (b) and fruits (c).

TABLE 1 Locations in which we confirmed the occurrence of *Cinnamomum chago* in Yunnan province, China, with geographical coordinates, altitude, number of mature individuals, area of occupancy and habitat type.

Locations	Geographical coordinates	Altitude (m)	Mature individuals	Area of occupancy (km ²)	Habitat type
La-Guo	99°55'9.20"E 25°33'8.90"N	2,310	12	3.22	Forest plantation
Xin-Cun	99°56'33.40"E 25°34'8.23"N	2,296	12	1.96	Forest plantation
Shun-Bi-Xiang	99°56'28.35"E 25°34'13.27"N	2,249	14	0.41	Forest plantation
Da-Shi-Ba	99°10'24.24"E 25°45'49.70"N	2,317	14	27.69	Secondary evergreen broadleaved forest
Nan-Mu-Ping	99°16'35.03"E 25°33'46.79"N	2,357	12	26.91	Secondary evergreen broadleaved forest
<i>Total</i>			64	60.19	

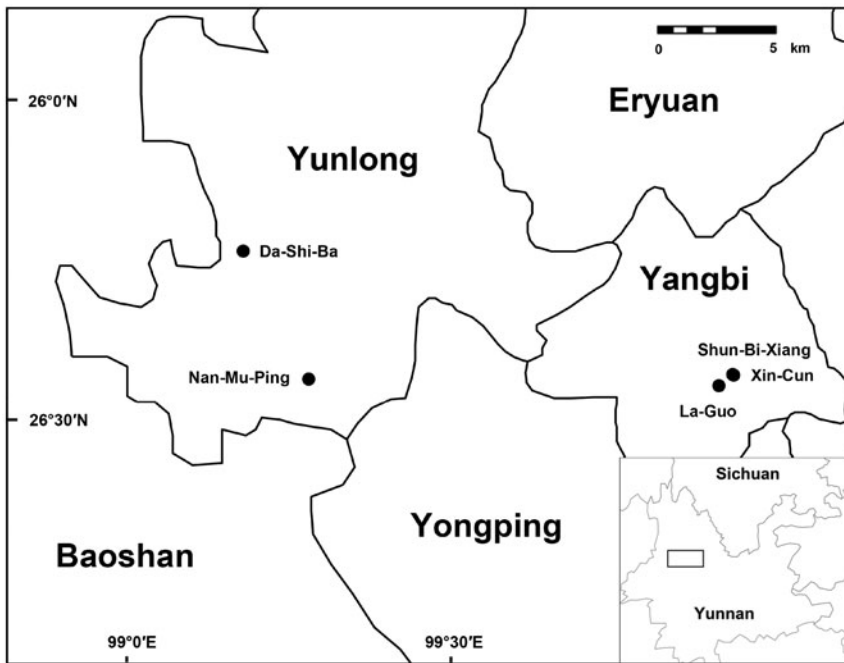


FIG. 1 The locations in which *Cinnamomum chago* was located in Yunnan province (La-Guo, where the species was first found, and four additional locations).

2009). The habitat of *C. chago* is of two types: secondary evergreen broadleaved forest and *Juglans regia* plantations. The populations in plantations (Table 1) are potentially exposed to high-frequency anthropogenic disturbance. None of the five populations lie within a protected area.

Expansion of pastoral activities and deforestation, and commercial utilization of the seeds and wood of *C. chago*, were detected in all five locations. In Nan-Mu-Ping *C. chago* had been felled to make furniture and other items. In all locations mature seeds of *C. chago* were collected by villagers and sold after processing. We found mature seeds gnawed by rodents, especially in Shun-Bi-Xiang, Xin-Cun and La-Guo, which are near villages. Our preliminary germination test indicated that the seeds of *C. chago* have deep dormancy, and our field observations indicate that healthy mature seeds begin to germinate under natural conditions in 1–2 years and that the germination rate is < 0.1%. We hypothesize that overexploitation is one of the most significant threats to *C. chago*, as a result of which, combined with slow germination, regeneration is probably poor. We did not observe any seedlings or saplings of *C. chago*.

In summary, we found < 100 mature *C. chago*, and its habitat has been degraded by human disturbance, confirming this is a species with an extremely small population (Sun, 2013). *Cinnamomum chago* was not included in the Threatened Species List of China's Higher Plants (Qin et al, 2017). We recommend categorization as Endangered based on IUCN Red List criteria (IUCN, 2012) 2ab(i,ii,iii, v), and make three additional recommendations. Firstly, the local forestry department needs to prevent the collection of the seeds and wood of *C. chago*. Secondly, as all located individuals occur outside protected areas, each population

requires protection and monitoring (this strategy is already being implemented for other species with extremely small populations that do not lie in National Nature Reserves; Wang et al., 2016, 2017). Thirdly, as reintroduction has been successfully employed for other plant species with extremely small populations (Wade et al., 2016), such as *Euryodendron excelsum* (Shen et al., 2013), *Magnolia sinica* (Wang et al., 2016) and *Primulina tabacum* (Ren et al., 2010), seedlings should be propagated ex situ for this purpose.

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Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

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