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The distribution and ecology of the purple form of *Ficus montana* in western Thailand

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ABSTRACT. *Ficus montana* Burm. f. var. *purpurascens* (Blume) has previously only been recorded from Java, by Corner (1960). It is distinguished from the typical form of *F. montana* by the strong purple pigmentation on the underside of the leaves, which is retained throughout their development. During our study of *Ficus montana* phenology in Kanchanaburi Province, Western Thailand from May 2008 to April 2009 we recorded its presence for the first time in Thailand and compared its relative frequency and within-site distribution to that of the typical form of the plant. Plants grown from seed and cuttings, and comparisons of the pollinators of the two forms, provide an indication of the nature of this variation in leaf colour. Cuttings grown under similar conditions retained their leaf colour, all seeds from typical plants produced typical offspring, but purple-leaved plants produced a mixture. The pollinator of the two forms is the same species of fig wasp, *Kradibia* (= *Liporrhopalum*) *tentacularis* (Grandi). These results suggest the variation is due to an inherited colour polymorphism.

KEY WORDS: Agaonidae, fig tree, leaf colour, polymorphism, Western Thailand.

INTRODUCTION

Ficus montana Burm.f. and its pollinator fig wasp (*Liporrhopalum tentacularis* (Grandi), syn. *Kradibia tentacularis* (Grandi), Agaonidae) have been intensively studied under laboratory conditions, but this small fig tree is relatively poorly known in the wild (Raja et al., 2008a,b; Tarachai et al., 2008; Zavodna et al., 2005). *F. montana* is a widely-distributed functionally dioecious species (Subgenus *Sycidium*, Section *Sycidium*) recorded from Myanmar, Thailand, Peninsular Malaysia, Java, Sumatra and Borneo (Berg & Corner 2005). Despite its wide distribution, *F. montana* is recorded infrequently and Berg (in Berg and Corner, 2005) commented that it was "remarkably… poorly represented in herbarium collections". This lack of records reflects its cryptic growth form: it is a small shrub, often less than 50 cm tall, with stems that are often thinly-spaced and emerge above-ground within other vegetation, and small inconspicuous figs (Fig. 1). Leaf shape is also variable: entire, lobed or toothed, and sometimes varies within the same plant. It also frequently lacks any figs to help distinguish it from young plants of other *Ficus* species. Population sizes are also typically small.

In his review of the fig trees of Thailand, Corner (1965) recorded *F. montana* from Chanthaburi, Nakhon Sawan and Ratchaburi provinces, mainly from riparian situations, but he did not mention the purple-leaved colour form of the plant. Even in the recently published; *Ficus*, in Flora of Thailand vol. 10 part 4, Berg (2011) did not describe the purple leaf form of this species. Originally described as a separate species, *F. montana* Burm.f. var. *purpurascens* (Blume) Corner (1960) has previously only been recorded from Java. It is distinguished from the typical form of *F. montana* by the strong purple pigmentation on the underside of the leaves, which is retained throughout their development (Fig. 2). In the field, the upper side of the leaves also sometimes appear to be a darker shade of green. Within plants, leaf colouration is consistent, either purple or green below, but young leaves of the typical form are sometimes purple beneath, although this quickly disappears once they are fully open.

Here we record for the first time the presence of the purple form of *F. montana* in Thailand, record its relative frequency and compare its within-site distribution to that of the typical form of the

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plant. Plants grown from seed and cuttings, and comparisons of the pollinators of the two forms, provide an indication of the nature of this variation in leaf colour.

METHODS

Ficus montana herbarium specimens (recently determined by C.C. Berg) in the Chiang Mai Herbarium (CMU) and in the Bangkok Forest Herbarium (BKF) were examined in January 2007 and February 2009 respectively to look for examples of specimens with purple leaves. We also carried out surveys for *F. montana* plants growing in nine stream-side locations in Western Thailand (Fig. 3) in 2008 and 2009. Their location, leaf colour and leaf shape were recorded. Cuttings were taken and a small number of mature figs that were present were removed to determine plant sex, to compare pollinators and to grow progeny under controlled conditions.

Pollinator females were reared from male figs obtained from a purple-leafed individual in Phu Toei, Suphan Buri in February 2009. They were compared with fig wasps from green-leafed plants collected from Erawan National Park, Kanchanaburi and the CIFOR estate, Bogor Java, Indonesia.

RESULTS

No specimens of *F. montana* var. *purpurascens* were found in the herbarium collections. *F. montana* was present along most of rocky stream beds in western Thailand that were examined, though it was never abundant (Table 1: no plants were detected at Sai Yok Noi waterfall). The plants were all growing in moderately shaded situations, either on rocks or stream-side sediments, with the tree canopy immediately above them or close by. *F. montana* var. *purpurascens* was present at several of the sites, but at others all the plants had the typical, green leaves. Where present, purple-leaved plants were usually in a minority, with the exception of the stream below the Ta Pern Kee Noi waterfall, where most of the plants had purple-coloured leaves. Overall, 19% of the 89 plants were of var. *purpurascens*.

Purple- and green-leaved plants were often found growing in close proximity, sometimes with stems inter-mixed, and there were no obvious ecological differences in the substrates where they were established, nor the amount of cover/shade from the trees above them. The spatial inter-mixing of the two colour forms can be seen in their distribution along the stream at Erawan (Table 2). Purple-leaved forms of both male and female plants were present, and leaf colour was also independent of leaf shape.

When cuttings of the purple form obtained from Erawan were grown in the same soil as plants with typical colouration they maintained their original colouration, indicating that the colour variation is not environmental in origin. Only green-leaved progeny were reared from three figs on three green-leaved female plants. 31 seedlings were grown from one fig on a single purple-leaved female parent (Fig. 4); nine were green-leaved, the rest purple-leaved. There were no intermediates.

Some of the fig wasp pollinators reared from typical and purple-leaved plants were *Liporrhopalum tentacularis* (Grandi). This is the normal pollinator across Indonesia and Thailand (Wiebes, 1994). However, individuals of a second, yellow, *Liporrhopalum* species were also reared from the single var. *purpurascens* fig collected at Phu Toei, together with individuals of *L. tentacularis*. Further collecting will be needed to establish the nature of the relationship between this second agaonid species and *F. montana* var. *purpurascens*.

DISCUSSION

In Western Thailand, *F. montana* is typically a species of riparian habitats, whereas further south, in Sumatra and Java, it occurs more generally in open forest undergrowth, degraded forest and open spaces including parks (Zavodna et al., 2005, SGC Pers. Obs.). Its more restricted distribution in Thailand presumably reflects the more seasonal rainfall experienced in the western and northern parts of its range.

F. montana var. *purpurascens* has apparently not been reported previously other than from Java, yet purple-leaved plants were present at most of the western Thailand sites we surveyed. The pollinator fig wasp *L. tentacularis* was reared from male

plants with both green and purple leaves, supporting the conclusion of Corner (1960) that they represent colour forms of the same species, though the relationship with a second species of pollinator remains unexplained. Furthermore, the consistency in leaf colour of individuals grown from cuttings, and that green-leaved progeny were obtained from a purple-leaved parent, indicate that the difference is likely to reflect a genetic dimorphism, rather than an environmentally-induced response. Leaf colour is not restricted to one or other plant sex (both male and female purple-leaved plants were

Table 1. *Ficus montana* colour morph frequencies in western Thailand. Note that it is often difficult to distinguish between adjacent individuals because of the spreading growth form of the plants, and the frequencies are therefore only approximate.

Province	Location	Year	Typical	Purple
Kanchanaburi	Pha Tad	2008	3	0
	Sai Yok Yai	2008	1	0
	Dai Chong Tong waterfall	2008	8	6
	Erawan National Park	2009	18	6
	Huai Mae Khamin	2009	31	0
	Chaloem Rattanakosin National Park	2009	2	0
	Kra Teng Jeng Waterfall	2010	>40	0
Suphan Buri	Ta Pern Kee Noi waterfall, Phu Toei National Park	2009	1	5
Phetchaburi	Kaeng Krachan National Park	2009	8	0
Total			>112	17

Table 2. The sequence of colour forms of *Ficus montana* along the western bank of the Erawan waterfalls stream, arranged from north-south. The distance between plants 1 and 24 was approximately 1,500 metres.

Plant	Leaf colour	Plant	Leaf colour
1	Green	13	Green
2	Green	14	Purple
3	Green	15	Green
4	Green	16	Green
5	Green	17	Green
6	Purple	18	Green
7	Purple	19	Green
8	Green	20	Green
9	Purple	21	Green
10	Green	22	Green
11	Purple	23	Green
12	Purple	24	Green

Figure 1. *Ficus montana* Burm.f.: A. habit; B. entire leaves; C. lobed leaves and D. figs.

Figure 2. *Ficus montana* Burm.f. var. *purpurascens* (Blume) Corner: A. habit; B. and C. lobed/toothed leaves; D. entire leaves and figs.

recorded) and appears to be independent of leaf shape (as with typical plants, some purple-leaved individuals had simple leaves, others had leaves that were lobed or toothed). In addition, our observations suggest that green leaves may display simple genetic dominance over purple leaves, but formal breeding experiments would be needed to confirm this.

Red or purple pigmentation on the underside of mature leaves is common amongst understory plants growing in shady conditions in tropical forests (Lee et al., 1979). In most plants, including *Ficus* species, this colouration results from the accumulation of anthocyanins (Lee and Collins, 2001). Proposed benefits for having an anthocyanin layer have included increased heat retention and 'back-scattering' of light to increase rates of photosynthesis. Both these mechanisms have recently been discounted, and it has been suggested that its key benefit may be to provide protection for plants that are shaded for much of the day, but are also subject to occasional damaging irradiance from brief periods of exposure to bright sunlight (Hughes et al., 2008). The *F. montana* growing along stream and rivers in Thailand will be exposed to just such a mixture of light and shade conditions, but purple-leaved individuals are nonetheless in a minority at most sites, suggesting that the costs associated with anthocyanin accumulation in the leaves often outweigh its potential benefits.

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