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Field surveys of natural populations of *Begonia* L. in Thailand

THAMARAT PHUTTHAI[1], MARTIN SANDS[2], KITICHATE SRIDITH[1]

ABSTRACT. Field surveys of natural populations of the genus *Begonia* L. (Begoniaceae) were undertaken in all floristic regions of Thailand from June 2007 to May 2008. Among the currently recognized species 30 were collected from various habitats on a range of substrata; terrestrial, epiphytic and lithophytic. Natural populations of all Thai begonias occur only near streams or waterfalls or in other humid places, such as moist bark or rocks, from near sea-level in eastern and peninsular Thailand to mountain summits over 2,000 m in the North of the country. Based on taxon abundance and distribution, the begonias collected fall roughly into three regional groups, namely Northern, Central and Peninsular species. Only one species, *Begonia integrifolia* Dalzell, is found in many parts of the country and another two, *Begonia sinuata* Wall. ex Meisn. var. *sinuata* and *B. variabilis* Ridl., occur in two of the above regional groups, being found in both the South-eastern and Peninsular floristic regions. All other taxa collected were recorded from only one floristic region of Thailand.

KEY WORDS: Surveys, Populations, *Begonia*, Thailand.

INTRODUCTION

The genus *Begonia* L. (Begoniaceae) is one of the largest genera in the world with more than 1,500 species already described (Kiew, 2005; Hughes, 2008; Sands, 2001). They are either annual or perennial herbs, found on moist rocks along streams, on the forest floor or sometimes on the humid bark of trees in undisturbed forest. They typically occur together with members of various other herbaceous taxa that thrive in the same habitats, such as species of Orchidaceae, Rubiaceae and Zingiberaceae. The diagnostic characters of the genus *Begonia* are: annual or perennial, terrestrial or epiphytic herbs with a tuber or rhizome; leaves usually with an oblique base; flowers zygomorphic, unisexual: male flower usually with 2–4 free perianth segments, androecium actinomorphic or slightly to strongly zygomorphic with 8 to many stamens, anthers mostly capitate, dome-shaped or boat-shaped (very few taxa), free or fused at the base; female flower usually with 2–5 free perianth segments, styles 2–3, fused at base; stigmatic surface spiral-, kidney- or sometimes crescent-shaped; fruits with 1–3 ± equal or unequal wings, or wingless. The genus occurs in various vegetation types, from low elevations near sea-level to the summits of high mountains (ca 2,500 m).

[1] Herbarium, Princess Maha Chakri Sirindhorn Natural History Museum & Centre for Biodiversity of Peninsular Thailand (CBiPT), Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, Thailand 90112.

[2] Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK.

The first and only treatment of *Begonia* in Thailand was published by Craib (1931). In this account he reported 45 species, of which 22 were first described by Craib himself in earlier papers which are cited in it. The genus is distributed widely throughout the country and the present study contributes towards a future taxonomic review of the genus in Thailand.

The purpose of this paper is to document the remaining natural populations of the genus *Begonia* in Thailand based on field surveys during a period of about a year in terms of habit types and habitats. In addition, observations on the natural ecology provide fundamental data for a future flora treatment and the conservation of natural populations remaining in Thailand.

METHODS

Field surveys

Wide ranging surveys of natural populations of the genus *Begonia* were conducted, mostly in conserved areas such as national parks, wildlife sanctuaries and non-hunting areas, They were undertaken during the period from June 2007 to May 2008. Twenty-four study sites of *Begonia* populations in all the Thai floristic regions were selected; three in the Northern region, three in the North-eastern; two in the Eastern; two in the Central, four in the South-eastern, two in the Southern and eight in the Peninsular (Fig. 1 A).

The floristic regions in Thailand used in the present study are in accordance with Smitinand (1958).

Data Collecting

Plant collections were made with field notes and photographs. Specimen processing followed methods recommended in Forman (1998). Voucher specimens are deposited in the Forest Herbarium (**BKF**), Department of National Parks, Wildlife and Plant Conservation, Ministry of Natural Resources and Environment, Bangkok, Thailand and in the Herbarium of the Department of Biology (**PSU**), Princess Maha Chakri Sirindhorn Natural History Museum, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, Thailand.

Identifications

Species were identified according to the current morphological species concept because taxonomic revisionary work of the genus for Thailand is still in progress. Doubtful specimens were left unidentified. New species and perhaps some nomenclatural changes can also be expected in due course.

Habits and Habitats Analysis

The habit and phenology of all *Begonia* populations found in this study have been noted and recorded and correlation with their habitats is considered below.

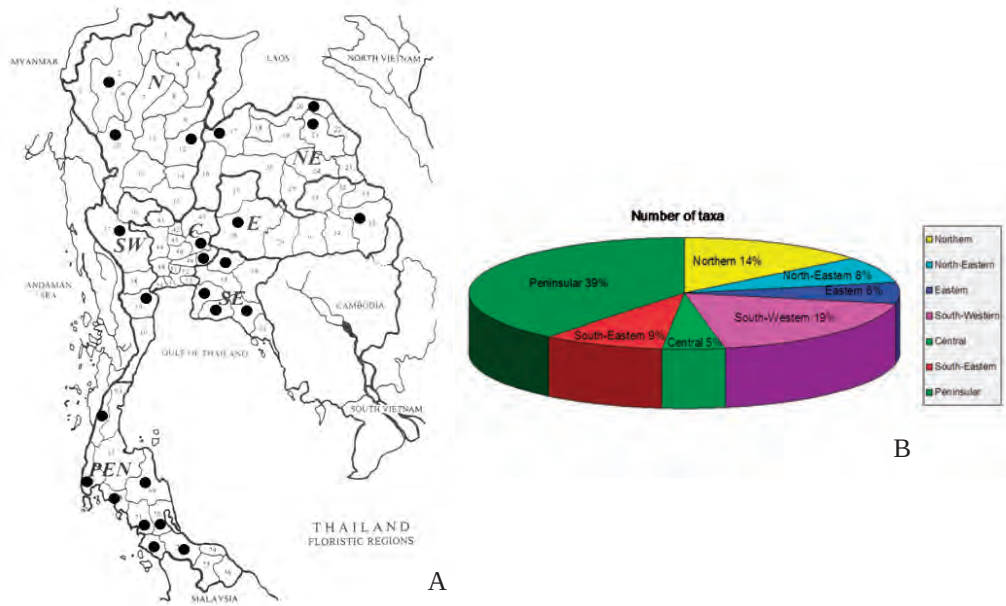

Figure 1. Study sites in the present survey of natural populations of begonias and the percentage of the species found in each floristic region of Thailand: A. Sites of natural populations in Thailand studied during field surveys from June 2007–May 2008; B. Percentage of *Begonia* taxa in the floristic regions.

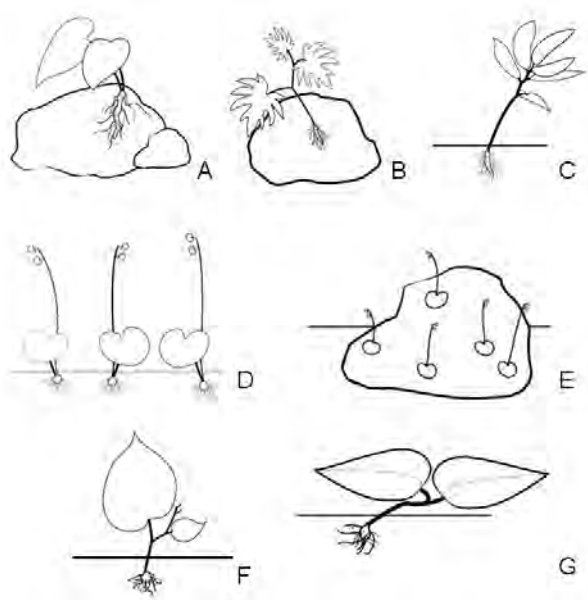

Figure 2. Habits of *Begonia* in Thailand: A, B. lithophytic habit with creeping rhizome; C. terrestrial habit with creeping rhizome; D.– G. terrestrial habit with or without tubers: D. plant with tuber and with aerial stems very short or absent ; E. plant without an underground stem; F, G. plant with erect to sub-erect distinct aerial stems.

Table 1. Taxa of Thai *Begonia* species in the floristic regions of Thailand according to the field populations surveys during the period June 2007 – May 2008. Names of taxa used in the present work are those currently accepted. Further study in preparing a revision of the Thai species for a Flora account may result in some changes.

Taxon	Thailand Floristic Regions						
	N	NE	E	SE	C	SW	PEN
Begonia alicida C.B.Clarke						X	
B. brandisiana Kurz							X
B. cardiophora Irmsch.							X
B. cathcartii Hook.f. & Thomson	X						
B. demissa Craib						X	
B. elisabethae Kiew							X
B. incerta Craib							X
B. integrifolia Dalzell	X	X	X	X			X
B. kerrii Craib			X				
B. laciniata Roxb.	X						
B. martabanica A.DC.	X	X	X				
B. murina Craib					X	X	
B. obovoidea Craib						X	
B. palmata D.Don	X	X					
B. pumilio Irmsch.							X
B. rabilii Craib				X			
B. rimarum Craib						X	
B. saxifragifolia Craib							X
B. siamensis Gagnep	X						
B. sibthorpioides Ridl. var. *grandifolia* Craib							X
B. sinuata Wall. ex Meisn. var. *sinuata*				X			X
B. smithiae Geddes							X
B. soluta Craib	X						
B. tricuspidata C.B.Clarke							X
B. vagans Craib							X
B. variabilis Ridl.				X			X
B. wrayi Hemsl.							X
Begonia sp. 1							X
Begonia sp. 2							X
Begonia sp. 3							X
Begonia sp. 4							X
Begonia sp. 5							X

Table 2. Thai *Begonia* species according to their habitats as observed in the course of field population surveys during the period June 2007–May 2008.

Taxon	Habitats					
			Lithophyte			
			Limestone			
	Terrestrial	Epiphyte	Outcrops in shady place	Degraded in open place	Sand-stone	Granite
Begonia alicida C.B.Clarke	X			X		
B. brandisiana Kurz			X			
B. cardiophora Irmsch.			X			
B. cathcartii Hook.f. & Thomson	X					
B. demissa Craib			X			
B. elisabethae Kiew	X					
B. incerta Craib			X			
B. integrifolia Dalzell	X		X			X
B. kerrii Craib					X	
B. laciniata Roxb.						X
B. martabanica A.DC.	X		X		X	
B. murina Craib			X			
B. obovoidea Craib	X					
B. palmata D.Don	X				X	
B. pumilio Irmsch.			X			
B. rabilii Craib			X			
B. rimarum Craib			X			
B. saxifragifolia Craib			X			
B. siamensis Gagnep	X				X	
B. sibthorpioides Ridl. var. *grandifolia* Craib			X			
B. sinuata Wall. ex Meisn. var. *sinuata*		X				X
B. smithiae Geddes	X					X
B. soluta Craib				X		
B. tricuspidata C.B.Clarke			X			
B. vagans Craib	X		X			
B. variabilis Ridl.						X
B. wrayi Hemsl.						X
Begonia sp. 1			X			
Begonia sp. 2			X			
Begonia sp. 3			X			
Begonia sp. 4			X			
Begonia sp. 5			X			

RESULTS AND DISCUSSION

Growth habits

All *Begonia* species encountered in the field population surveys were either terrestrial or lithophytic annual or perennial (mostly succulent) herbs with rhizomes or tubers. They are suberect and unbranched or weakly branched.

Annual species

For annual plant species, only one type of growth habit was recognized, namely plants having a small one-leaved aerial stem without any kind of underground stem (Fig. 2 E.) for example *B. sibthorpioides* var. *grandifolia* (all taxon authors are given in Table 1).

Perennial species

Three common types of growth habit of perennial *Begonia* occurring in Thailand were recognized:

1. Plants with erect aerial stem very short or scarcely evident and an underground (or rock-crevice) creeping rhizome (Fig. 2 A.); *B. obovoidea, B. smithiae*.

2. Plants with distinct erect aerial stem and underground (or rock-crevice) creeping rhizome, which can be divided into two subtypes (Fig. 2 B, C):

2.1. Plants without distinct swollen nodes (Fig. 2 B) e.g. *B. palmata, B. siamensis*

2.2. Plants with distinct swollen nodes that, in some taxa, produce adventitious roots (Fig. 2 C.) e.g. *B. wrayi*

3. Plants with underground (or rock-crevice) tubers, which may be classified into three groups (Fig. 2 D, F, G):

3.1. Plants with a very short, mostly one-leaved, aerial stem (Fig. 2D) e.g. *B. brandisiana*

3.2. Plants with a distinct, many-leaved, erect aerial stem (Fig. 2F) e.g. *B. murina*

3.3. Plants with a sub-erect, many-leaved aerial stem (Fig. 2G) e.g. *B. vagans, B. variabilis*

Habitats

The types of habitat in which *Begonia* species in Thailand are able to grow (Table 2) can vary greatly, even though in most cases the habitats are confined to undisturbed primary forest. It is probably due to the wide variation in habitat that there are a significant number of species that were found throughout all phytogeographical regions of Thailand. Moreover, some species occur in more than one or many habitat types (Table 2) and some are able to grow both as terrestrial plants and as lithophytes such as Begonia alicida, *B. integrifolia* and *B. martabanica* However, there are many species which were discovered to be confined to restricted habitats, never having been collected from elsewhere. These restricted species and their endemism is discussed below under the various habitat types.

Terrestrial habitats

Only three species are restricted to this habitat type, namely *Begonia cathcartii, B. elisabethiae* and *B. obovoidea*. This is a rare habitat for the genus *Begonia* in Thailand, since most species are lithophytes. *B. obovoidea* is found in seasonal vegetation in Northern Thailand (dry deciduous forest) only during the humid season, while the other two are found on the forest floor along streams in undisturbed moist evergreen forest in Peninsular Thailand.

Limestone outcrops in shady places

15 species were found to occur in this type of habitat, namely *Begonia brandisiana, B. cardiophora, B. demissa, B. incerta, B. pumilio, B. rabillii, B. rimarum, B. saxifragifolia, B. sibthorpioides* var. *grandifolia, B. tricuspidata* and the five unidentified species (see Tables 1 and 2). It is also interesting to note here that most limestone habitats in Thailand remain unexplored. Given the localized occurrence of begonia species in this kind of habitat and the frequency of isolated populations, it is very probable that more undescribed species remain to be discovered on Thai limestone outcrops. So far, five unidentified species from these field surveys have been found on the limestone outcrops in the Peninsular region. It is unfortunate that the vegetation over the limestone outcrops, where most *Begonia* species have been found, is very fragile and sensitive to disturbance by many human activities such as tourism and limestone mining. Thus species yet to be discovered may already be threatened by extinction.

Degraded limestone in open places

This habitat is unusual, being rarely found in Thailand, but was found to be home to just two species: *Begonia alicida* and *B. soluta*. The habitat develops in open areas which are exposed throughout the day to sunlight. This environment is generally unfavourable to the occurence of *Begonia* species, being too dry and hot, especially in the dry season. Nevertheless, it supports allopatric plant species which may encourage speciation and many endemic herbaceous species can be expected in such habitats. It is interesting that an endemic species of *Begonia, B. soluta* was recorded from this unique habitat in Thailand only at Doi Hua Mod, Umphang, Tak Province at more than 1,000 m and was found only in the rainy season. The other species found on degraded limestone, at Thong Pha Poom, Kanchanaburi Province at less than 300 m also occurs as a terrestrial species at a much lower altitude and also occurs on the forest floor in other places in Kanchanaburi as well as in India and Myanmar.

Sandstone

Only one species of *Begonia, B. kerrii,* was found to be restricted to sandstone, and is found only in the rainy season Two species also found on sandstone are *Begonia palmata* and *B. siamensis*, but they are also found in terrestrial habitats at Doi Inthanon, Chiang Mai province and Phu Luang, Loei province at over 1,000 m. This distribution may be due not only to the substrate type, but also to altitude.

Granite rocks

There are three species of lithophytic *Begonia, B. laciniata , B. variabilis* and *B. wrayi* which are confined to granite rocks in streams, mostly evident in the rainy season. In addition, there are two other species, which are found on granite rocks but also either as tree-bole epiphytes which occur only on the wet bark of large trees near the ground (*Begonia sinuata var sinuata*) or as terrestrial plants on the forest floor in the rainy season (*B. smithiae*).

Taxa Abundance and scattering according to the Thailand floristic regions.

More collection sites were recorded from Peninsular Thailand than from any other floristic region during the field population surveys (Table 1; Fig. 1B). This might be attributable to the year round humid conditions in this region, favouring the growth of begonias in general, being annual or perennial herbs that are always found flowering in the humid period of the year (see also under '*Growth habit*' above).This is also true in the South-eastern floristic region where, during the present study, species were collected from four collection sites.

Similarly, most *Begonia* species (19 out of 32) recorded during the field surveys were collected from the Peninsular region; about 60 percent of all Thai *Begonia* species (Table 1). However, this percentage might alter when data from the specimen studies in various herbaria is added. A humid climate and moist rock habitats, occurring most commonly in the Peninsular region, account for the recording of the majority of Thai begonias in this part of the country (see also under the topic of '*Growth habit*'). Moreover, most taxa (17 out of 19, ca 90%) that were found in Peninsular Thailand are endemic.

Regarding the occurrence of taxa from the field population surveys, three major regional groups of *Begonia* can be recognized. They are distinguished from each other in accordance with three related groups of floristic regions in Thailand (see Table 1):

1. Northern taxa, which are those occurring in the Northern, North-eastern and Eastern floristic regions, where there is a drier climate with a distinct dry season. The species are *Begonia cathcartii, B. kerrii, B. martabanica, B. palmata, B. siamensis* and *B. soluta.*

2. Central taxa, occuring in the more humid Central, South-eastern and South-western floristic regions with a shorter dry season, namely *Begonia alicida*; *B. demissa, B. murina, B. obovoidea, B. rabilii, B. rimarum, B. sinuata var. sinuata* and *B. wrayi.*

3. Peninsular taxa, which only occur in the relatively aseasonal Peninsular floristic region. These are *Begonia brandisiana, B. cardiophora, B. elisabethiae, B. pumilio, B. saxifragifolia, B. sibthorpioides var. grandifolia, B. sinuata var. sinuata, B. smithiae, B. tricuspidata, B. vagans, B. variabilis, B. wrayi* and five as yet unidentified taxa.

The only common species that is found widely in Thailand is *Begonia integrifolia,* perhaps because it is tolerant of a range of habitats (Table 2). Only two taxa, namely *B. sinuata* var. *sinuata* and *B. variabilis*, occur in both the South-eastern and Peninsular regions, probably because of the similarity of their habitat and climatic conditions. Otherwise, the three regional groups of taxa indicated above are quite distinct from each other, corresponding to the three main groups of floristic regions, associated with differing climate. For the first group, the Northern species, the climate is drier than in any of the other regions, with a distinct dry season. The Central taxa enjoy a more humid climate with a shorter dry season than that for the Northern species, a climatic condition somewhat

intermediate between that of the North and the Peninsula. The third group, the Peninsular species, belong only to the Peninsular floristic region, where newly recorded unidentified taxa have been discovered. In the present study, many areas in Peninsular Thailand were included which were previously unexplored with regard to begonias. It was noted that most begonias recorded in the current field study have limited distributions, especially those in the Peninsular region.

There is little doubt that the taxon composition of all three *Begonia* regional groups in Thailand may have been influenced by the flora of neighbouring countries. Thailand is situated in two important phytogeographical regions of the world, namely the Continental-Southeast Asian region (related to the North, North-east, East and Central parts) and the Malesian region (influencing the southern part of peninsular Thailand) Thus, Thailand's flora has been influenced northwards and westwards by the Himalayan-Chinese and Indo-Burmese flora, eastwards by Indo-Chinese floras and southwards by the Malesian flora (Whitmore, 1987).

Furthermore, when the data from more herbarium specimens in various herbaria are added later, the abundance and distribution of the genus *Begonia* in Thailand will be better understood.

Notes on some morphology adaptations of Begonia according to habitats in association with the conservation of populations.

Considering the morphology of begonias occurring mostly in dry places, some, like other xerophytic plants of tropical forests such as orchids, possess special adaptations for living in a habitat which is seasonally dry. There are only a few terrestrial *Begonia* species living in moist evergreen forest in Thailand, the remainder occurring in dry habitats either as epiphytes on tree trunks or on various kinds of (moist) rocks along streams or in closed forest. However, some *Begonia* species are able to survive in open sunny situations, for example lithophytic species on degraded limestone rocks (see Habitats section and Table 2). Morphologically, most *Begonia* species are more or less succulent herbaceous plants. Either the leaves or stems (the latter may also be underground) are succulent to withstand the dry conditions, mostly on rocks, like other herbs in evergreen forest. Similar morphological adaptations, especially succulence, are also, for example, to be found in the families Gesneriaceae and Orchidaceae (Levitt, 1980). Physiologically, *Begonia* species have to have special adaptations to resist the seasonal drought conditions as is the case in most vegetation in Thailand. Like other plants, they can resist drought in two ways, either as annuals or perennials. The annual *Begonia* species maintain their populations and resist drought as 'drought avoiding plants' (Levitt, 1980), dying off in the dry season and leaving only seeds on the substrate, which regenerate in the next rainy season. Plants in this category, for example *Begonia sibthorpioides* var. *grandifolia*, are small, without any underground parts and are able to produces flowers and seeds very fast in the wet season. Perennial begonias maintain their populations in a different way, resisting the drought conditions as 'drought tolerant plants' (Levitt, 1980). These species are geophytes, with underground storage organs, namely tubers or rhizomes. In the dry season, the aerial parts, such as the leaves and aerial stems, die off leaving only underground tubers or rhizomes remaining in rock crevices withstanding the drought conditions in the dry season. Fresh aerial parts develop again only in the rainy season.

Most *Begonia* species in Thailand are very localized, with perhaps some of their specific habitat requirements still poorly understood, and accordingly endemism is quite high. Furthermore, the composition of the *Begonia* flora differs from one floristic region of Thailand to another. Many begonias may occur in inaccessible places where it is currently difficult to study them. Moreover, the natural habitats of begonias are extremely fragile, for example degraded limestone, limestone outcrops in evergreen forest and sandstone platforms. These are very vulnerable to human activities and indeed species may be becoming extinct even before they can be described. Habitat conservation therefore, must be promoted if *Begonia* populations are to be protected.

It is to be noted that there are a considerable number of taxa previously recorded by Craib (1931), *Begonia acetosella* Craib, *B. bilocularis* (Wight) Craib, *B. curtisii* Kurz, *B. debilis* King var. *punicea* Craib, *B.discreta* Craib, *B. festiva* Craib, *B. fibrosa* C.B. Clarke, *B. grantiana* Craib, *B. grata* Geddes, *B. haniffii* Burkill, *B. incondita* Craib, *B. inflata* C.B.Clarke, *B. isoptera* Dryand. ex. Sm., *B. notata* Craib, *B. prolixa* Craib, *B. pumila* Craib, *B. putii* Craib, *B. rubrovenia* Hook., *B. socia* Craib and *B. subviridis* Craib which could not be included in the present study because they could not be found in their originally recorded localities during the field population surveys. This may be due either to the fluctuations of their growing seasons from year to year, or to the populations having been lost completely from those localities. It may also be because of identification and nomenclatural difficulties which will only be resolved when the research leading to a taxonomic revision of the genus *Begonia* in Thailand is completed.

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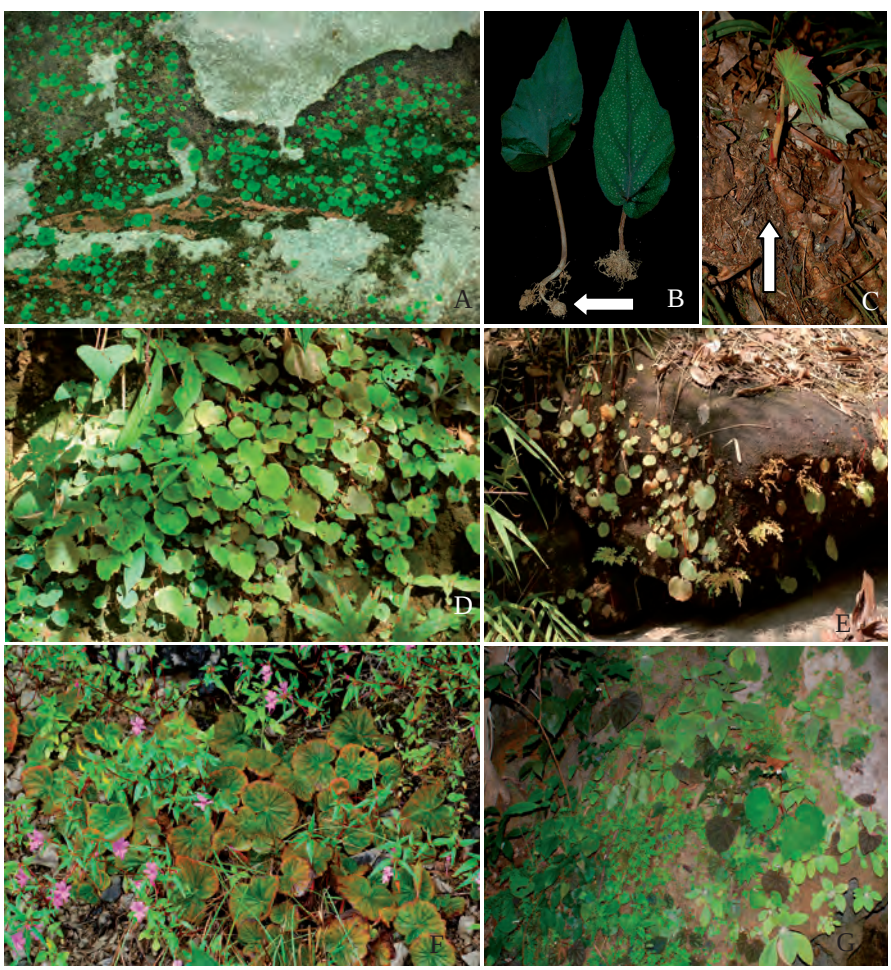

Figure 3. Growth habits and habitats of *Begonia* in Thailand: A–C. habits: A. annual plant taxon (*B. sibthorpioides* Ridl. var. *grandifolia* Craib); B–C. perennial plant taxa with underground stems: B. tuber of *Begonia* sp. (arrow); C. rhizome of *B. palmata* D.Don (arrow); D–G. habitat types: D. terrestrial habitat (*B. martabanica* A.DC.); E–G. lithophytic habitats: E. sandstone rock (*B. kerrii* Craib); F. open degraded limestone (*B. soluta* Craib); G. shaded limestone G. (*B. integrifolia* Dalzell).