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The Begonias of New Guinea – an overview

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Key words

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Symbegonia

Abstract A brief introduction to the family *Begoniaceae* and genus *Begonia* is followed by an outline of the key morphological characters of begonias and a review of the sections (*Diploclinium*, *Petermannia* and *Symbegonia*) and species of the genus occurring in New Guinea. The essential characteristics of these sections are described and the range of habitats of begonias in New Guinea are briefly considered. Aspects of collecting begonias are discussed and some ways forward for future research on *Begoniaceae* in New Guinea are suggested.

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INTRODUCTION

Begoniaceae is a remarkable family in that all but one species belong to the huge pantropical genus, *Begonia*, which comprises more than 1 500 species (Kiew 2005: 27). It is now the sixth largest genus of flowering plants (Frodin 2004: 776), with 1 524 species by early 2009 (Govaerts 2009) (see also p. 273) and rapidly approaching the point of exceeding 1 600 predicted by Sands (2001: 161). Earlier classifications of the family contained several genera, for example Klotzsch (1855), who recognised as many as 37, De Candolle (1864) and later Irmscher (1925). Now, however, since the reduction of the New Guinea endemic genus *Symbegonia* to sectional rank (Forrest & Hollingsworth 2003: 208), only *Hillebrandia sandwicensis* Oliv. is maintained as a distinct, monotypic genus. It is endemic to the Hawaiian islands and the only palaeoendemic genus in the island group (Clement et al. 2004). Essentially, compared with *Begonia* (see below), it is characterised by having a semi-superior ovary with parietal placentation, dehiscence between the styles and eight to ten tepals in two distinct whorls. The genus *Begonia* was first described by Linnaeus (1753) and subsequently circumscribed in more detail by others such as Irmscher (1925), Doorenbos et al. (1998: 63), Kiew (2005: 26) and Sands (2006: 1).

KEY CHARACTERISTICS

Despite a vast range of variation within the genus *Begonia*, with relatively few exceptions, the majority of its very many species can *usually* be recognised instantly by exhibiting three key characteristics:

– asymmetrical leaves with one side usually larger than the other;
– separate male and female flowers with petals and sepals usually concolorous and indistinguishable (tepals);
– an inferior, usually 3-winged ovary with the styles often branched and coiled.

Including these, a *relatively* limited suite of characters associate with each other in astonishingly numerous combinations providing the basis of section and species distinction and, beyond this, begonias exhibit seemingly endless variation in very detailed characters. The many sections of the genus (66), and to some extent their species, are distinguished by characters such as tepal numbers, inflorescence form and position, style and anther morphology and fruit form and function, including distinctive differences in placentation.

Morphological variation in New Guinea

Leaves vary greatly between species in New Guinea. In size they range from less than 4 cm long as in *B. brassii*, *B. monantha* and *B. symparvifolia*, to more than 20 cm long as in *B. lauterbachii*, and in shape from suborbicular as in *B. subcyclophylla* and *B. symhirta*, to broadly ovate as in *B. brachybotrys*, elliptic as in *B. torricellensis* or obovate – sometimes quite narrowly so – as in *B. randiana*. In a few species the lamina is almost equilateral, as in *B. physandra* but, usually, the size and shape of the largest basal lobe provides an important character. It varies from rounded and obvious, as in *B. augustae* and *B. pulchra*, to small and inconspicuous on an almost cuneate base as in *B. calliantha* and *B. randiana*, to not discernable, as in *B. strictinervis*, where the larger side of the lamina only differs from the other by extending further down the petiole for a short distance. Leaf margins vary from more or less entire or remotely and shallowly dentate, as in *B. lauterbachii*, remotely serrulate as in *B. brachybotrys*, to deeply dissected as in *B. bipinnatifida*, *B. oligandra*, *B. pinnatifida*, *B. serratipetala*, and *B. warburgii*, the last five referred to, and illustrated, by Hallé (1972: 360). *Begonia serraticauda* has a distinctive long and narrowly acuminate tip which itself is serrate. Variation in colour and patterning of the leaves can also be distinctive, for example the white or pinkish marginal marking of several species in sect. *Symbegonia*, the white-spotting on *B. humboldtiana* leaves, or the purplish green with deep red intervein markings of *B. brevirimosa* (Plate 1b).

Begonias have separate male and female flowers with the sepals and petals concolorous (tepals). In most New Guinea species (sect. *Petermannia* and sect. *Symbegonia*), the male flower usually has two tepals, and the female flower usually five, sometimes four. The male flower tepals may be more than 1 cm long as in *B. symsanguinea* and *B. vanderwateri* or less than 5 mm long as in *B. flexicaulis* and *B. symgeraniifolia*. Similarly, female flower size can vary but, in addition, tepal size and shape often show a gradation within a single flower. The stamens, with the anthers usually yellow, vary in number from less than 10 in *B. pulchra* to about 60 in *B. rhodantha*. The size

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and shape of the torus, on which they are inserted, can also be diagnostic, being often noticeably elongated in species of sect. *Symbegonia*, ranging to globose and subsessile as in *B. vanderwateri*. The styles are usually yellow and bifurcate, the arms bearing a coiled or spiral stigmatic band although this can vary considerably, and it is straight in *B. brassii*. The inferior, usually 3-winged and trilocular ovary has axile, usually bilamellate placentas.

In begonias belonging to sect. *Petermannia* and sect. *Symbegonia*, which include the great majority of New Guinea species, inflorescences are usually protogynous with the female flowers basal and few (often only two) and the male flowers more numerous and distal. However, the type and complexity of inflorescences varies and sometimes, in New Guinea, can be distinctive, such as the basal inflorescence of *B. archboldiana* or the axillary cluster of flowers of *B. brachybotrys*. The fruits of *B. brachybotrys* become rather fleshy and ripen to red but in most species the fruit is a winged capsule. The wings particularly may be specifically distinct in size and shape, varying from rounded or blunt and subequal as in *B. lauterbachii*, *B. papuana* and *B. subelliptica*, to angled as in *B. mooreana* and *B. serratipetala*. Some species have one wing much larger than the other two as in *B. kaniensis* (Plate 1a), the only New Guinea climber, and *B. acaulis*, one of only a few acaulescent species in New Guinea. Both are in sect. *Diploclinium*.

Often species may be additionally characterised by less obvious or more detailed differences, such as the occurrence of bracteoles which are usually absent in New Guinea species but do occur in *B. montis-bismarckii* and *B. monantha*. The stipules and bracts can provide very distinctive specific characters, being either early-caducous or persistent and marcescent. They can vary considerably in size and shape and, as in *B. rhodantha*, can taper to a very long, conspicuous fine tip, itself ciliate. The indumentum too can vary greatly with a range of distinctive hair types, from completely glabrous as in *B. augustae* and *B. brachybotrys*, to densely strigose-hairy as in *B. pentaphragmifolia*, *B. randiana*, *B. sharpeana* and *B. toricellensis*.

THE SECTIONS OF *BEGONIA* AND DISTRIBUTION

The genus *Begonia* is found throughout tropical and subtropical regions worldwide, with the exception of tropical Australia and the Pacific eastwards beyond Fiji and Vanuatu to the Galapagos islands. To the 63 sections of *Begonia*, throughout its range, recognised by Doorenbos et al. (1998), two have been recently added and, with the new sectional status of *Symbegonia*, there are currently 66 (Tebbitt 2005: 97). Of these, 18 are represented in the Southeast Asian region (Myanmar (Burma) to the western Pacific islands). When their distribution in this area is considered, broadly speaking the number of sections is greatest in the west, with nine in Myanmar, ten in Thailand and eight in Peninsular Malaysia, declining eastwards, with only three in both the Philippines and New Guinea, despite high species numbers. By 2007, in the region as defined above, there were 521 species, the three most species-rich floras being those of New Guinea (79 spp.), Borneo (95 spp.) and the Philippines (104 spp.) (Hughes 2008: vii). Recently, 16 more species from Borneo have been published by Kiew & Sang (2007, 2009) bringing the number in Borneo to 111, the regional total to at least 537 and the generic total to 1531 (see p. 272). With many new species yet to be described, notably in Borneo, Sulawesi and New Guinea, the Southeast Asian regional total is expected to easily exceed 600 in due course.

Sections in New Guinea

In New Guinea, the large majority of begonias (55) belong to sect. *Petermannia* and relatively few to sect. *Diploclinium* (7) and sect. *Symbegonia* (13). Most *Diploclinium* species can be distinguished from species of sect. *Petermannia* by usually being stemless, creeping or lianescent, protandrous and with four male tepals (Plate 1a). *Petermannia* species in contrast have upright stems, are protogynous and have only two male tepals. Usually *Symbegonia* species can be distinguished from those of both the other sections by having the female tepals fused into a distinctive tubular 'corolla' (Plate 1d), sometimes the male tepals also partially fused and the stamens on an often elongated torus (Plate 1c and inset). Attention has been drawn to the difficulties of delimiting sections within *Begonia* (Doorenbos et al. 1998: 93) not least in distinguishing sect. *Diploclinium* from some others, including sect. *Petermannia*. Both are described and discussed in detail by Doorenbos et al. (1998), but there are quite a number of species which, in several characters, remain exceptions to their careful circumscription of the two sections. Even the partial fusion of the female flower tepals, perhaps the most obvious feature previously upholding *Symbegonia* as a distinct genus, is a character found in some *Petermannia* species such as *B. brevirimosa* and *B. serratipetala*. Indeed these two sections exhibit several other similarities, such as protogyny, tepal number, bifid placentae and partial fusion of both stamens and styles, and several phylogenetic studies between 1998 and 2001 support the placing of *Symbegonia* deeply within *Petermannia* with which it was shown to be paraphyletic. Nevertheless, Forrest & Hollingsworth (2003: 208) refer to good morphological synapomorphies, namely a distinctive androecium and, according to Tebbitt & MacIver (1999: 212, 215), unique anther endothecal cells. Accordingly, these features, together with the practical advantages of retaining *Symbegonia* as a discrete taxon separate from the very large sect. *Petermannia*, led to its transfer to *Begonia*, while still retaining its separate identity as a third, distinct New Guinea section.

Four further species of the present New Guinea total of 79 (*B. archboldiana*, *B. oligandra*, *B. physandra* and *B. warburgii*) cannot yet be placed with certainty in any of the three sections.

Section Diploclinium (Lindl.) A.DC.

Doorenbos et al. (1998: 94) chose to divide sect. *Diploclinium*, with more than 135 species, into three groups based on habit, namely, I: creeping (or lianescent); II: erect; and III: stemless (i.e. the stem much reduced or absent). Four of the seven New Guinea species (compared with more than 30 in the Philippines) belong to Group I, *B. bartlettiana* Merr. & L.M.Perry, *B. kaniensis* Irmsch., *B. sharpeana* F.Muell. and *B. subcyclophylla* Irmsch., one to Group II, *B. brassii* Merr. & L.M.Perry, and two to Group III, *B. acaulis* Merr. & L.M.Perry and *B. minjemensis* Irmsch. It is of interest to note that of the four species in Group I, *B. kaniensis* (Plate 1a) which climbs on trees to several metres and *B. sharpeana*, a stem-rooting scrambler on limestone, are lianescent species with almost symmetrical leaves and as such show a close similarity to species in the African sect. *Cristasemen* and the American sect. *Gobenia*. One of the species not yet confidently assigned to section, *B. physandra*, could well belong to Group I of sect. *Diploclinium*, but the discovery of 2-locular ovaries (Doorenbos et al. 1998: 219) may result in the need to establish a new section which might also include another of the currently unplaced species, *B. archboldiana*. The third unplaced species, *B. oligandra*, probably correctly belongs to sect. *Diploclinium*, but its placement in Group II remains doubtful.

Section Petermannia (Klotzsch) A.DC.

This section, as already indicated, is one of the largest in *Begonia*, now comprising over 250 species and accounting

Plate 1 Representatives of the three *Begonia* sections occuring in New Guinea. a. *Begonia kaniensis* Irmsch. (sect. *Diploclinium*); a climber, showing pendulous female flowers, an angular fruit wing much larger than the other two and male flowers having two of the four tepals pink with longitudinal markings; b. *Begonia brevirimosa* Irmsch. ssp. *exotica* Tebbitt (sect. *Petermannia*); showing striking leaf markings and inflorescence of male flowers; c. *Begonia* sp. (sect. *Symbegonia*); male flowers with stamens on an elongated torus (inset) and, in some species in the section, the tepals partially fused; d. *Begonia* sp. (sect. *Symbegonia*); female flowers with tepals fused into a distinctive tubular 'corolla' and sharply pointed equal ovary wings manifestly extending beyond the style base. Photographs: M.J.S. Sands.

for nearly half the total number in Southeast Asia (Hughes 2008). Even with 55 already described from New Guinea (e.g. *B. augustae* Irmsch. and *B. simulans* Merr. & L.M.Perry), it is most probable that many new species await description and will be predominately referable to sect. *Petermannia*. Although there are exceptions, most species are characterised by being protogynous with female flowers (often only two) at the base of the inflorescence and the male flowers having two tepals. The majority of species are frutescent and the relatively few that are repent or scandent can be distinguished from sect. *Diploclinium* species by their protogyny and tepal number. It may be noted that the fourth New Guinea species with the section to which it belongs not yet confirmed, *B. warburgii* K.Schum. & Lauterb., may prove to be best placed in sect. *Petermannia*.

Section Symbegonia (Warb.) L.L.Forrest & Hollingsw.

Species belonging to this section are all endemic to New Guinea and, in addition to the distinguishing sectional characters listed above, are often densely hairy and have the fruit wings more or less equal and usually manifestly extending beyond the style base (Plate 1d). To date 13 species have been recognised. These include *B. arfakensis* (Gibbs) L.L.Forrest & Hollingsw., *B. argenteomarginata* Tebbitt, *B. fulvo-villosa* Warb., *B. mooreana* (Irmsch.) L.L.Forrest & Hollingsw., *B. pulchra* (Ridl.) L.L. Forrest & Hollingsw. and *B. strigosa* (Warb.) L.L.Forrest & Hollingsw. For the remaining seven species, with epithets already occupied in Begonia, Forrest & Hollingsworth (2003: 208) provided new names by adding the prefix 'sym' to the earlier *Symbegonia* epithets, namely *B. symbeccarii*, *B. symbracteosa*, *B. symgeraniifolia*, *B. symhirta*, *B. sympapuana*, *B. symparvifolia* and *B. symsanguinea*. In addition to these species already published, more are being described in current studies of the section and I expect that there will be at least 11 new species and two new varieties, with two of the species listed above being reduced to varietal rank. As in the other sections, it is very probable that, after further collecting and study of existing herbarium material many more species will be discovered.

Begonia species in New Guinea

In New Guinea, of the 79 species described to date over a long period of intermittent publication (Fig. 1, Table 1), 61 have been recorded from Papua New Guinea and only 40 from Indonesian New Guinea (formerly Irian Jaya). This lower figure, for western New Guinea, almost certainly reflects under-collecting and can be confidently expected to rise. As previously noted (Sands 2001: 161, 167), it is very probable that many, as yet undescribed, species are represented in herbaria and undoubtedly others await discovery so that, in due course, the number of species in New Guinea as a whole may exceed 150. In the Bismarck Archipelago only one is recorded from the Admiralty Islands, three from New Ireland and four from New Britain. Although further exploration in several remote areas may certainly result in more species being found in New Britain, these lower species numbers represent a fall-off in numbers eastwards through the Solomon islands to the single species found in Fiji and Vanuatu. With only four of the current 79 species occurring elsewhere, endemism is particularly high in New Guinea, with the majority of species very localized, although *B. kaniensis* is found in many areas from the central mainland cordillera to southern New Ireland and, as Tebbitt (2000: 113) states, the widespread distribution of *B. brachybotrys* is exceptional. This species now includes *B. brachyptera* Merr. & L.M.Perry in synonymy (Tebbitt 2000: 114) and it is to be noted that Smith & Wasshausen (1984: 469) replaced *B. richardsoniana* Merr. & L.M.Perry (non Houllet) with the new name *B. mystacina* L.B.Sm. & Wassh.

Habitats

In New Guinea begonias are to be found from near sea level to nearly 3 000 m with *most* species occurring between 300 and 1 500 m. At these altitudes the very steep mountainous terrain,

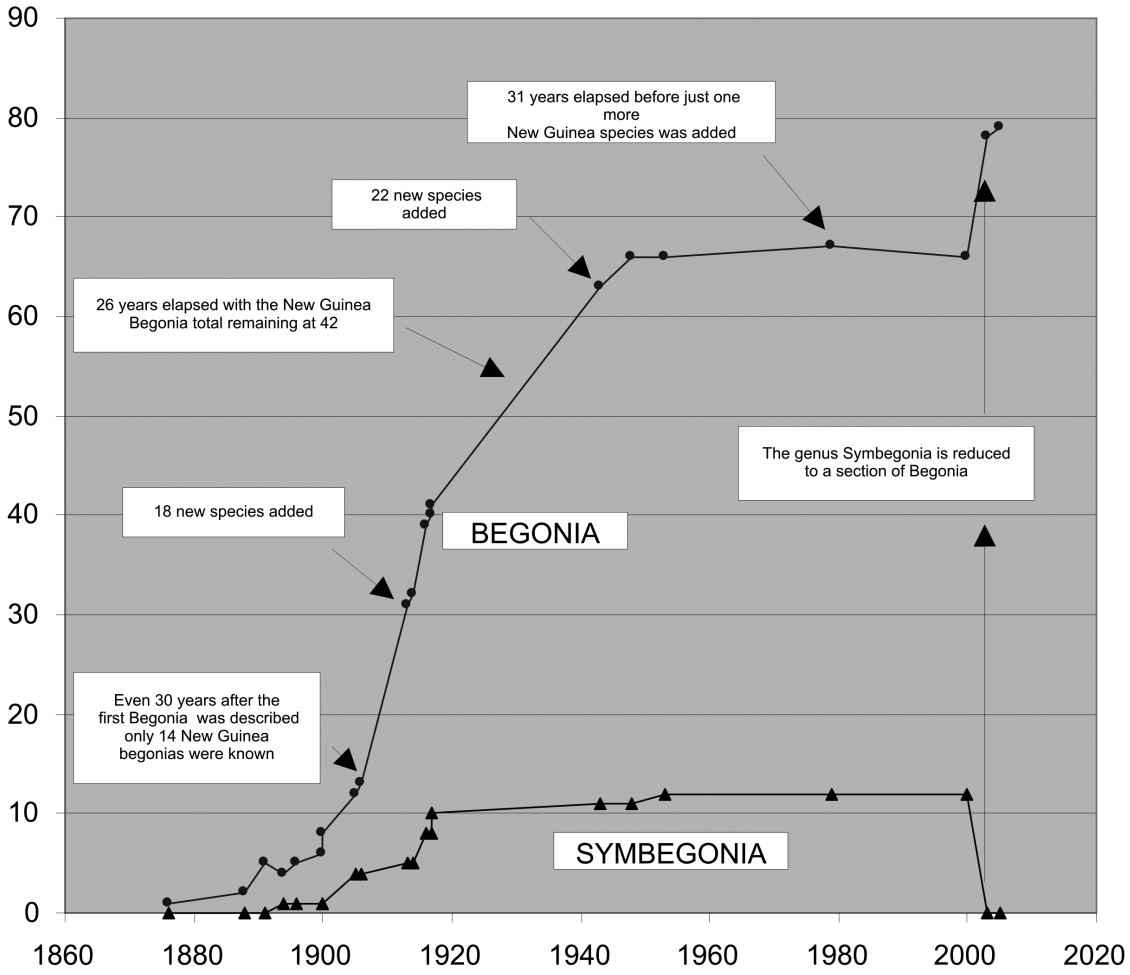

Fig. 1 Accumulation curve of accepted species of *Begonia* (●) and *Symbegonia* (▲) in New Guinea. Vertical axis: number of accepted species. Horizontal axis: species published (or the status changed) per year by Forrest & Hollingsworth (2003); Gibbs (1917); Gilli (1979); Hemsley (1896); Irmscher (1913, 1917, 1953); Smith (1906); Merrill & Perry (1943, 1948); Mueller (1876, 1888); Ridley (1914, 1916); Schumann & Lauterbach (1900); Tebbitt (2000, 2005); Warburg (1891, 1894, 1900, 1905).

Table 1 Publication history of *Begonia* and *Symbegonia*.

Author	Reference	*Begonia*			*Symbegonia*		
		New	Reduced	Total	New	Reduced	Total
Mueller	1876: 67	1		1			
Mueller	1888: 420	1		2			
Warburg	1891: 386–388	3		5			
Warburg	1894: 149		1	4	1		1
Hemsley	1896: 17	1		5			1
Schumann & Lauterbach	1900: 459	1		6			1
Warburg	1900: 458	2		8			1
Warburg	1905: 321–324	4		12	3		4
Smith	1906: 47	1		13			4
Irmscher	1913: 335–383	18		31	1		5
Ridley	1914: 289	1		32			5
Ridley	1916: 58–62	7		39	3		8
Gibbs	1917: 147–148, 215	1		40	2		10
Irmscher	1917: 102–103	1		41			10
Merrill & Perry	1943: 41–58	22		63	1		11
Merrill & Perry	1948: 160–161	3		66			11
Irmscher	1953: 507			66	1		12
Gilli	1979: 421	1		67			12
Tebbitt	2000: 114		1	66			12
Forrest & Hollingsworth	2003: 208	12		78		12	
Tebbitt	2005: 98–99	1		79			

often with fast flowing rivers, tends to limit the number of species that occupy *strictly* riverine habitats (Sands 2001: 167), and a considerable number grow instead in ever-wet locations such as damp forest gullies or dripping rock faces. Nevertheless, extensive field observation and the apparent requirements of many begonias in cultivations, suggest that, despite the usually evident need for a really moist habitat, most species thrive best when the substrate is reasonably well drained.

The following few species provide some representative examples of New Guinea habitats where begonias may occur. *Begonia augustae* and *B. stilandra*, are recorded as growing in damp valleys, on steep banks near streams and rivers or on slopes in rainforest. *Begonia brachybotrys* and *B. lauterbachii*, on the other hand, seem to be more adaptable, occurring in habitats that range from damp and shady places in *Nothofagus* or *Castanopsis* – oak forest, and even on an exposed landslide, to particularly wet locations such as a sago palm swamp or large rocks in stream beds and periodically flooded areas along creeks. *Begonia kelliana* is a gregarious ground herb 'plentiful in rainforest of lower mountain slopes' between 75 and 225 m, and, in contrast, *B. kaniensis* (Plate 1a), as a root climber, reaches a height of 3 m or more on trees in montane, mossy or ridge forest. Damp gullies and wet, shaded upper montane forest over 2 000 m are home to several species in sect. *Symbegonia* as well as *B. brassii*, *B. calliantha*, *B. fruticella* and others, while *B. brevirimosa* grows on the floor of dense shaded forest, the dark habitat no doubt contributing to the development of the conspicuous red marking on its leaves (Plate 1a). *Begonia physandra* and *B. sharpeana* are more unusual for New Guinea, occupying crevices in limestone.

COLLECTING BEGONIAS

It is very evident that, while existing specimens in herbaria already represent new species awaiting description, a great many parts of New Guinea still remain unexplored botanically and there is little doubt that many *Begonia* species have yet to be discovered. In Indonesian New Guinea in particular, specimens are mostly only known from expeditions along major river valleys leaving vast areas still covered in primary forest. Here, as in many other regions throughout the island and in New Britain, much more field work and collecting is required. What is needed are really well collected specimens with full field data and descriptions and, whenever possible, the results of wider field studies. Biological data about begonias, such as their phenology, pollinators, seed dispersal and detailed habitat and micro-climatic requirements, is still very limited. Furthermore, collectors should always be encouraged to obtain suitably preserved material for DNA studies and gather information on vernacular names and the local uses of species whenever the opportunity arises.

For those intending to collect begonias, the following suggestions may be helpful. Like other rather fleshy plants, it is particularly important, whether using spirit or a field dryer, to spread out, display properly and dry specimens as soon as possible. Particularly thick, fleshy stems should be crushed flat to facilitate quicker drying and field notes should always include the texture and contouring, as well as the colour and markings, if any, of both the upper and lower leaf surfaces, important features that are often overlooked and then lost in the drying process. Optimally both male and female flowers and fruits should be collected. Carefully pressed individual flowers can often be as useful for study (and sometimes more so) as flowers preserved in spirit, because the latter may become too delicate and fragile for dissection.

Whenever possible, one or more flowers should be carefully pressed and preserved separately to clearly display the number, size and shape of the tepals. For this purpose, cut off the expanded tepals of female flowers, with just enough tissue from the very top of the ovary to hold them together, and then press down with thumb or finger tip, preferably also pressing centrally on the styles so that each of the three (usually) can be displayed to best advantage. A male flower can be treated in the same way keeping the tepals together with a very small stub of pedicel and pressing down on the centre of the stamen cluster.

To press fruits to the best advantage, it helps to cut off one of the wings, preferably the smallest if they are markedly subequal, and press it separately so that the shape of each wing and its relationship to the capsule can be clearly seen. At the same time, if more than one is available, it is important to cut a transverse slice of a nearly ripe (but not nearly dehiscing) fruit at about the mid-point between the pedicel and the tepals. Such a transverse slice, about 1–2 mm thick, can usually quite easily be cut, even with a sharp bush knife and, when pressed and dry, can provide a valuable and immediate picture of the locule size and number and the placentation pattern.

FUTURE RESEARCH

Now, and in the future more than ever before, as well as the current need for more collecting, it is important that this and associated research, should be done collaboratively, involving as far as possible counterpart botanists within New Guinea as well as indigenous people with detailed local knowledge. In a very large genus like *Begonia*, with an ever increasing number of species, taxonomic treatments need to cover manageable units such as sections or smaller, recognisable species-groups for publication and sometimes they may need to be multi-authored. In *Begoniaceae*, because the sections effectively equate to separate genera in other families, it is suggested that, using the same principles as for the new generic level of 'An Interactive Key to Malesian Seed Plants' (The Malesian Key Group 2004), it could be practical and useful to provide an interactive key to the 18 sections of *Begonia* in the Southeast Asian region.

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