An Introduction to the New Guinea Database, with Notes on the Zingiberaceae, Specifically *Riedelia* Oliv.

R. JOHNS

Botanical Research Institute of Texas [BRIT], 509 Pecan St., Fort Worth, Texas, 46102 – 4060, U.S.A.
Email: mountjaya1@yahoo.com

Abstract

The entries for the family Zingiberaceae in the New Guinea database include records of over 1700 collections. Based on this information an overview of the family is presented. The extensive records in the database highlight several problems. A considerable number of collections in the family have not been identified at generic level (190 collections) and many collections in each genus are not identified at the species level. This particularly applies to the larger New Guinea genera: *Alpinia* Roxb. and *Riedelia* Oliv., respectively with 256 and 236 collections. In this paper particular attention is paid to the neo-endemic genus *Riedelia*, which is represented by 85 described taxa in New Guinea. The genus has not been revised since 1916.

Introduction

The objective of the New Guinea program at BRIT is to instigate a period of intensive botanical collecting of the flora through expeditions to both Papua and Papua New Guinea. These expeditions will be carried out in association with staff from National and Regional Herbaria. It is essential to collect 'high quality' herbarium materials, photographs, and living collections for the scientific study of the flora. The top set of collections from New Guinea will be deposited locally in the major National herbaria with duplicates sent to important international herbaria. Only this will provide an adequate basis for future studies of the flora of New Guinea.

A database is being developed to facilitate the study of the flora of New Guinea. It will not only enable the mapping of plant distributions but will also highlight areas where the flora is unknown or poorly know and will thus act as a guide for future expeditions. The database will also enable the production of species lists for given regions. Another benefit will be to

provide information for younger botanists and ecologists, for the study of plant diversity in New Guinea and also to access the major literature on the New Guinea flora. The database, which so far includes ca 300,000 herbarium collections, has considerable potential for use in herbarium management. It will also be an essential tool to identify conservation areas and to highlight biodiversity priorities for all levels of government in New Guinea.

1. The New Guinea database

The New Guinea database includes collections from the Indonesian Province of Papua, previously Irian Jaya (now divided into two Provinces) and Papua New Guinea. Because of its floristic associations with New Guinea, collections from the Aru (Aroe) Islands (Maluku Province) are included. Records are also included from the North Solomons Province (Buka and Bougainville), politically, part of Papua New Guinea. Extension of the database to the Solomon Islands would include all records for the biogeographical region known as Papuasia.

The New Guinea database is arranged to include:

A **species database**. The type collection of each species is recorded. The herbarium in which the type occurs is also recorded (holotype and isotypes where known), its place of publication, important literature, and general notes on each species and their ecology. The distribution is recorded and, where the species is endemic to New Guinea, this is recorded as a regional or a local endemic. A note is included if there are obvious nomenclatural problems. Synonyms are also recorded.

A **specimen database**. It is proposed to list all vascular plant collections from New Guinea in the database. So far nearly 300,000 records of vascular plants have been entered into the database(s). Each collection will be geo-referenced so that its location can be mapped.

Using the entries in the database it will be possible to produce distribution maps of expeditions and collections at the family, genus and species levels. This will be a valuable guide so that areas, which have been poorly collected, can be targeted for expeditions. Locality data will also enable the generation of species lists at provincial and sub-provincial levels as a basis for regional planning and conservation. From the database it will be possible to produce:

a) Lists of all plant species known from New Guinea, the Provinces and smaller regions within New Guinea;
b) Lists of species from selected plant families, and genera. It will

also be possible to map these.

c) Lists of plants endemic to the New Guinea region, and to map their patterns of distribution.

2. The family Zingiberaceae in New Guinea

The New Guinea region is one of the major centres of diversity for the family Zingiberaceae. Larsen *et al*. (1998) give the diversity of the family, worldwide, as ca 52 genera and 1,300 species. Based on the estimates of Newman (2007), New Guinea probably has over 300 species. In total New Guinea includes over 20 percent of the species worldwide. Over 1700 collections of Zingiberaceae have been databased from New Guinea; the database includes records of many species new to science. The database includes 240 species in 18 genera from New Guinea (Table 1). Newman (2007) lists six major genera from New Guinea: *Alpinia* Roxb., *Amomum* Roxb., *Etlingera* Giseke, *Hornstedtia* Retz., *Pleuranthodium* (K. Schum.) R.M.Sm., and *Riedelia* Oliv. He also lists several genera for New Guinea, which he thinks are cultivated or possibly naturalised, these include *Curcuma* L., *Globba* L., and *Zingiber* Mill. Many of these genera have 'endemic' species listed from New Guinea (Newman *et al*., 2004). Their status will require detailed taxonomic studies as all genera and species are poorly studied. Potentially many new species remain to be collected and described from the large areas that are still un- or under-collected. In Table 1 the number of collections in a genus, percentage of endemism, and the number of species recorded from Papua, Papua New Guinea and the whole island is enumerated for selected genera. These figures will change as our knowledge of the family in New Guinea increases.

3. History of research on Zingiberaceae in New Guinea

The Zingiberaceae in New Guinea were revised in several important papers by Schumann (1899, 1904), Valeton (1913a, b, 1914, 1917), and Ridley (1886, 1916, 1923). Few general papers have been published since the work of Valeton and Ridley. The recent works of B.L. Burtt and R.M. Smith are the first modern attempt to examine the family in Malesia (Burtt & Smith, 1972a, b; Smith, 1975, 1990a, b, c).

To date, the family in New Guinea has received little attention. With the exception of *Alpina*, *Pleuranthodium*, and *Riedelia*, the family is poorly represented in New Guinea. Of the 223 species recorded from New Guinea by Newman *et al*. (2004), 90 taxa are referred to *Riedelia* and 46 to *Alpinia*.

4. The collections of Zingiberaceae in New Guinea

In Papua the majority of species are described from several key areas (Fig. 1). The Kepala Burung (= Vogelkop or Bird's Head, see Fig 1A). L.S. Gibbs

Table 1. Collection data on selected genera of Zingiberaceae from New Guinea.

	No of taxa	No of collect. [1]	Endemism %	Species Recorded Pap.	PNG	Both
Alpinia	63	473 [256] [3]	96	31	23	8
Amomum	14	91 [37]	92	6	7	1
Curcuma	6	73 [20]	57	3	1	3
Etlingera	16	69 [23]	100	8	6	2
Globba	1	9 [4]	0	-	1	-
Guillainia	4	18 [-]	100	1	-	-
Hornstedtia	3	108 [24]	66	2	-	1
Pleuranthodium	22	63 [10]	100	5	14	3
Riedelia	85	686 [251]	100	42	32	11
Zingiber	6	19 [-]	50	1	2	3
Zingiberaceae indet.	191[2]					
Totals	**231***			**99**	**85**	**33**

[1] Total number of collections in the category.
[2] Number of collections not identified to genus.
[3] [ ] Number of collections not identified to species level.

Nine species have be added from database records for 'doubtful' genera in Papua New Guinea:

Hedychium [1 species - *H. coronarium*]
Phaeomaria [2 species - *P. anthokaphina*, *P. novoguineensis*]
Thylacophora [1 species - *T. pognocheila*]
Naumannia [1 species - *N. insignis* (*Riedelia insignis*)]

In addition Riswan and Setyowati (1996) listed *Kaempferia* (3), and *Nanochilus* (1) from Papua. *Pleuranthodium* (*Psychanthus*) is also not listed by Riswan and Setyowati (1996) from New Guinea.

organised an expedition to the Arfak Mountains in 1913-1914. Gjellerup made additional collections of gingers from the area in 1912. These ginger collections were described by Valeton in Gibbs (1917). More recent expeditions to this area contain many collections that have not been critically studied. These include collections by staff of the Forestry Department (BW series), collections by P. van Royen and H. Sleumer from the Kebar Valley,

and the expeditions to the N.E. Kepala Burung, funded by the MacArthur Foundation, which were made in the 1990's. Staff from Herbarium Bogoriense and the Manokwari Herbarium have also collected in the area.

The other key areas in Papua are Mt Jaya (Carstensz) (Fig. 1B) and the Lorentz River Basin (Fig. 1C), both to the S of the central Ranges. C.B. Kloss was the botanist/collector for both of the Wollaston Expeditions to Mt Carstensz. The second expedition resulted in the collection of many 'new' species of gingers (Ridley 1916). Some of these species have been recently recollected by the staff of Freeport (Environmental Department) and also during the recent expeditions to Mt Jaya by expeditions organised from the Royal Botanic Gardens, Kew (Johns *et al*. 2006). Collections have also been made in the same area by staff from Herbarium Bogoriense and the Manokwari Herbarium. The Lorentz basin was collected by several expeditions and many species were described by Valeton (1913b). The main collectors were Lorentz, von Roemer, and Versteeg. Some species have also been described from the early collections in the vicinity of Jayapura (= Hollandia, see Fig. 1D). The extensive collections from Papua by H.J. Lam in 1920-1921, and L.J. Brass in 1938-1939, and collectors in the BW series all postdated the most recent revisions of the gingers from Papua.

The history of Zingiberaceae research in Papua New Guinea parallels that of Papua. In 1875 Nauman collected in the Bismark Archipelago (Fig. 1L) as did several latter collectors, including Nymann in 1899 and Peekel from 1908 to 1938. In 1885 Forbes made extensive collections (Ridley 1886) from the Sogeri Division (Fig. 1I), which included many Zingiberaceae. The last collections from Papua New Guinea studied by specialists in the family (Valeton 1914) were those of Schlechter in 1909 from the Toricelli Mts. (Fig. 1E) and various collectors in the Madang and Morobe Provinces (Fig. 1F, G, H). There have been extensive collections from Papua New Guinea since 1916, especially in the Central Highlands (Fig. 1J) and the upper reaches of the Fly River (Fig. 1K) but all postdated any specialist studies of the Zingiberaceae.

In common with many plant families in New Guinea the species of Zingiberaceae are very poorly known. While many tree species have been widely collected (both lead herbaria in New Guinea were part of the Forestry Departments; Papua – BW series; PNG – NGF and LAE series), the majority of herbaceous species, including the gingers, are poorly known. As shown in Table 2 most species of gingers are known from only the types, or two to three collections. This is also characteristic of many herbaceous plant families in New Guinea, where over sixty percent of the species are often represented by a single collection. Another fifteen to twenty percent of species are usually represented by only two to three specimens.

Figure 1. Critical sites to be visited for the recollection of the duplicates of types of *Riedelia* in New Guinea. For location of sites see text.

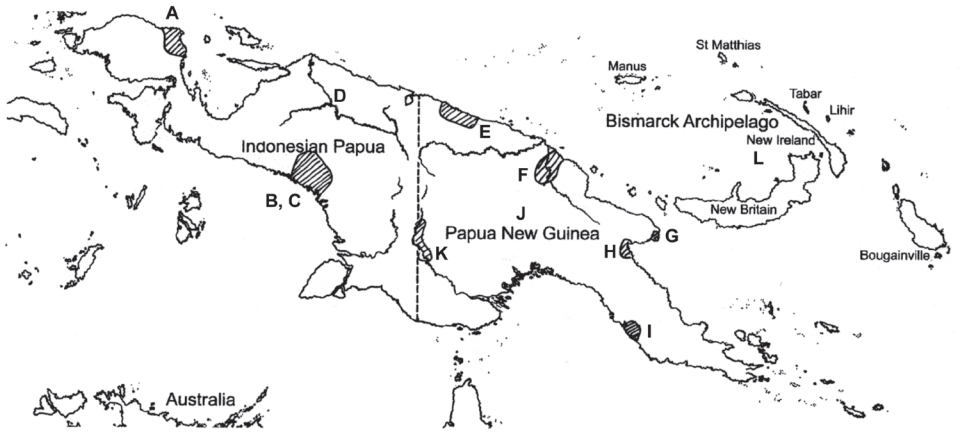

Table 2. Number of specimens collected (1-10+) per species from selected genera of Zingiberaceae from New Guinea.

Collections per species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Alpinia	46	13	11	8	5	1	-	-	1	3
Amomum	15	1	-	-	-	-	-	-	-	-
Curcuma	4	1	-	-	-	-	-	-	-	2
Pleuranthodium (Psychanthus)	13	8	6	8	-	-	-	1	-	-
Riedelia	32	10	5	7	4	2	-	-	2	8
Zingiber	2	-	-	1	-	1	1	-	-	-

5. The genus Riedelia nom cons. *in New Guinea and Maluku*

The genus *Riedelia* was described by Oliver in *Hooker's Icon. Pl.* 15: 15 (1883), based on a collection by J.G.F. Riedel from Pulau Buru in the Maluku. The type species is *Riedelia curviflora* (Plate 1). *Riedelia* was conserved against *Riedelia* Cham. described in the Verbenaceae in 1832, while another

homonym *Riedelia* Meisn., a Brazilian genus described in Ericaceae in 1863 was not validly published (Rickett & Stafleu, 1959). Valeton (1914) incorrectly lists *Riedelia curviflora* Oliv. as a synonym of *Riedelia lanata* (Scheff.) Valeton, a widespread species from both Papua and Papua New Guinea.

Newman *et al*. (2004) list two genera as synonyms of *Riedelia*, *Nyctophylax* Zipp. described by Zippelius in 1829, based on *N. alba* Zipp. a nomenclatural synonym (Greuther *et al*. 2000) and *Thylacophora* Ridl. (1916) based on *T. pogonocheila* Ridl., collected by C.B. Kloss from Mt Carstensz (Mt Jaya) in 1912. *Hedychium lanatum* Scheff. was described in 1876 based on a collection by J.E. Teysmann (*Teysmann 6741*), collected from the MacCleur Gulf in New Guinea in August of 1871.

The monotypic genus *Naumannia* Warb. [*Bot. Jahrb*. 13: 452 (1891)] was based on *N. insignis*. The genus was distinguished by its petaloid lateral staminodes and the flower lacks a labellum. It is possibly related to *R. corallina*. Further collections are required from the type locality, Sattelburg, Morobe Province, to establish its status. Readers should also note that the status of *Nyctophylax alba* Zipp. (1829), the first record listed as a synonym of *Riedelia* by Newman *et al*. (2004), is at present not understood.

The publication of the 90 taxa (species and varieties) of *Riedelia* from New Guinea is summarised in Table 3. The major papers were published by K. Schumann (1904) and a series of papers by Valeton (1907, 1913a, 1913b, 1914, 1917). Ridley (1916) described the collections made by C.B. Kloss from Mt Carstensz (Mt Jaya). There have been no detailed studies of the genus *Riedelia* since the publications of Valeton and Ridley. In 1979 P. van Royen published five species from the subalpine and alpine regions of New Guinea, and A. Gilli (1983) published two new species from the highlands of Papua New Guinea (Table 2).

6. Distribution of Riedelia

The genus *Riedelia* is distributed from the Maluku to New Guinea, extending to the Solomon Islands (Bougainville) and is represented by ninety taxa in New Guinea (Fig. 2). Of the 686 collections of *Riedelia*, 251 still remain unidentified. All species are endemic to New Guinea, but *R. curviflora* possibly extends its range to Papua from the Maluku. Forty-two species are known to be restricted to Papua, 32 species to Papua New Guinea, and 11 species occur throughout the island. A more detailed understanding of their distribution patterns must await more detailed study.

Species identified as *Riedelia* are also recorded from Borneo (Sarawak [*Ashton 17713*; *Meijer* 21217], and Kalimantan [*Kostermans 5122*]), Sulawesi [*Burley 3511*, *3667I*], and the Philippines (Newman, *pers. com*.). The taxonomic identity of these collections requires further study.

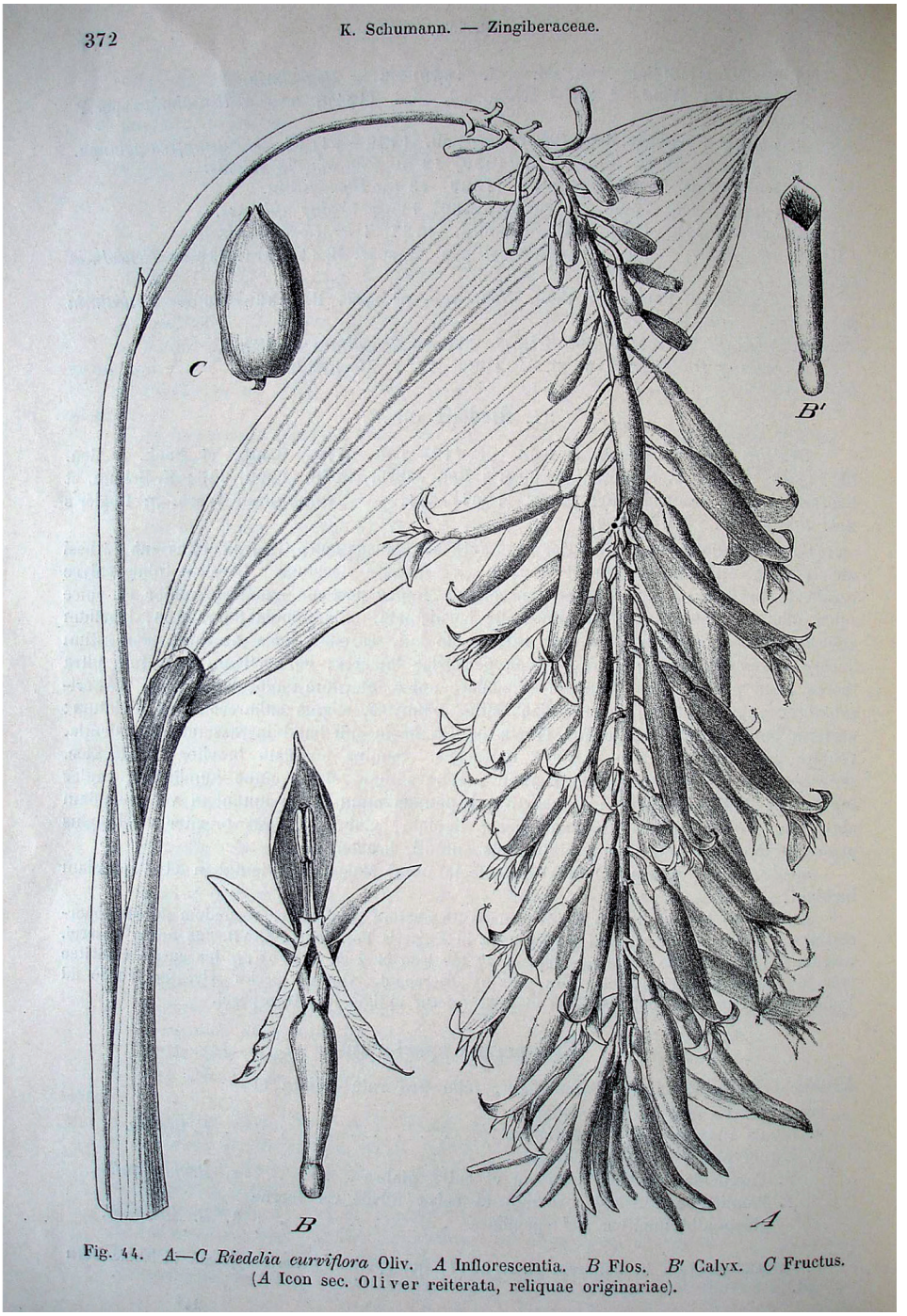

Fig. 44. *A—C Riedelia curviflora* Oliv. *A* Inflorescentia. *B* Flos. *B'* Calyx. *C* Fructus. (*A* Icon sec. Oliver reiterata, reliquae originariae).

Plate 1. *Riedelia curviflora* Oliver. A. Inflorescence; B. Flower; B'. Calyx; C. Fruit. A-C from Riedel s.n., Pulau Buru, Maluku. Reproduced from: Schuman, 1904.

Table 3. Publication dates for the species of *Riedelia* [86 taxa]. Source of Type collection: ° Moluccas, [1] Papua, [2] Papua New Guinea

Date	Author	Publication
1883	Oliv.	Hooker's Icon. Pl., Pl. 15: 15. [1 taxon] *R. curviflor*a ° [Type species for genus].
1904	K. Schum.	Pflanzenr. IV, 46: 373-440. [7 taxa] *R. affinis* (Ridl.) K. Schum.[2], *R. albertisii* (K. Schum.) K. Schum.[2], *R. bismarckii-montium*[2], *R. macrantha* (K. Schum.) K. Schum.[1], *R. monophylla*[2], *R. nymanii*[2], *R. stricta*[2]
1907	Valeton	Bull. Dép. Agric. Indes Néerl. 10: 2. [1 taxon] *R. geanthus* [1]
1913a	Valeton	Icon. Bogor. 4(3): t. 373-375. [3 taxa] *R. corallina* (K. Schum.) Valeton [2], *R. erecta* [1], *R. lanata* (Scheff.) Valeton [1]
1913b	Valeton	Nova Guinea 8: 962-980. [30 taxa] *R. alata* [1], *R. angustifolia* [1], *R. areolata* [1], *R. arfakensis* [1], *R. brachybotrys*[1], *R. branderhorstii* [1], *R. brevicornu* [1], *R. epiphytica* [1], *R. eupteron* [1], *R. fulgens* [1], *R. graminea* [1], *R. graminea* var *diversifolia* [1], *R. graminea* var. *elata* [1], *R. graminea* var. *nana* [1], *R. hollandiae* [1], *R. lanata* (Scheff.) *Valeton forma ligulata* [1], *R. macranthoides* [1], *R. maculate* [1], *R. maxima* [1], *R. montana* [1], *R. montana* var. *arfakensis* [1], *R. montana* var. *golianthensis* [1], *R. orchidoides* (K. Schum.) Valeton [1], *R. paniculata* [1], *R. pterocalyx* [1], *R. robusta* [1], *R. sessilanthera* [1], *R. sessilanthera* var. *euodon* [1], *R. subulocalyx* [1], *R. tenuifolia* [1]
1914	Valeton	Bot. Jahrb. Syst. 52: 70-96. [21 taxa] *R. bidentata* [2], *R. decurva* (Ridl.) Valeton [2], *R. dolichopteron* [2], *R. ferruginea* [2], *R. flava* Lauterb. ex Valeton [2], *R. geluensis* [2], *R. geminiflora* [2], *R. grandiligula* [2], *R. latiligula* [2], *R. longifolia* [2], *R. longirostra* [2], *R. macrantha* var. *grandiflora* [2], *R. macrothyrsa* [2], *R. microbotrya* [2], *R. minor* [2], *R. monticola* [2], *R. rigidocalyx* Lauterb. ex Valeton [2], *R. schlechteri* [2], *R. umbellate* [2], *R. urceolata* [2], *R. urceolata* var. *sessilifolia* [2]
1916	Ridley	Trans. Linn. Soc. London, Bot. 9: 222-226. [11 taxa] *R. aurantiaca* [1], *R. bicuspis* [1], *R. ferruginea* [2] (nom. illeg.), *R. hirtella* [1], *R. klossii* [1], *R. ligulata* [1], *R. longisepala* [1], *R. pulcherima* [1], *R. purpurata* [1], *R. triciliata* [1], *R. wollastonii* [1]
1917	Valeton	see Gibbs, Fl. Arfak Mts. 102. [2 taxa] *R exalata* [1], *R. montana* var. *puberula* [1]
1923	Ridley	Proc. Roy. Soc. Queensland 34: 19. [2 taxa] *R. lanatiligulata* [2], *R. whitei* [2]
1979	P. Royen	The Alpine Flora of New Guinea 2: 860-866. [5 taxa] *R. curcumoidea* [1], *R. marafungensis* [2], *R. rosacea* [2], *R. subalpina* [2], *R. suborbicularis* [2]
1983	Gilli	Ann. Naturhist. Mus. Wien, B 84: 46-47 ("1980"). [2 taxa] *R. capillidens* [2], *R. geluensis* Valeton var. *microflora* Gilli [2]
1990	R.M. Smith	Edinburgh J. Bot. 47: 65. [1 taxa] *R. cordylinoides* (Ridl.) R.M. Sm.[1]

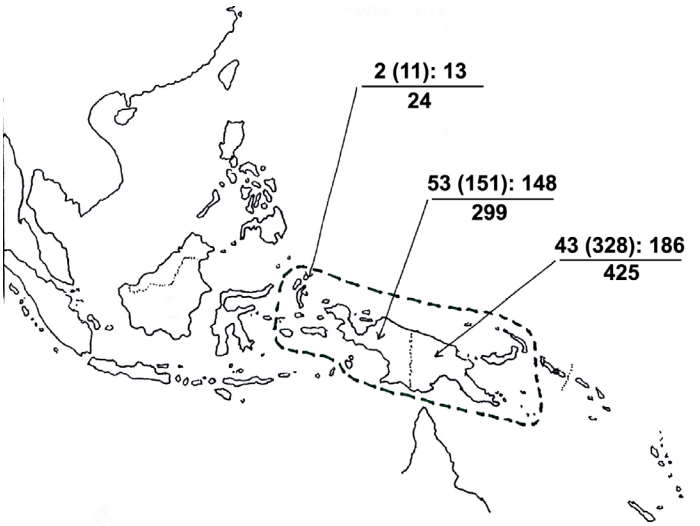

Figure 2. Distribution and diversity of *Riedelia*. Distribution of *Riedelia* (**------**). Diversity of *Riedelia* in Maluku, Papua and Papua New Guinea expressed as:

$$\frac{\text{No. of species (no specimens) : No. indet collections}}{\text{Total number collections}}$$

7. Ecology of Riedelia *in New Guinea*

Most species of *Riedelia* grow as terrestrial species in the rainforest from sea level to 3,200 to 3,700 m. Data is presented in Table 4 to show the altitudinal zonation of the common genera of Zingiberaceae from New Guinea. The three most common genera in New Guinea, namely, *Alpinia*, *Pleuranthodium*, and *Riedelia*, occur at most altitudes up to 3,700 m (Table 5). At their upper altitudes species can be locally common in subalpine forest. Most collections however do not have the altitude recorded. Although both *Alpinia*, and *Pleuranthodium* are recorded above 3,500 m altitude, both have fewer collections above 1000 m. *Riedelia* in contrast is more strongly represented by collections from the mid- and upper montane forests, particularly so in PNG. It is difficult to interpret these Tables as they may merely reflect collection patterns rather than actual zonation patterns. Higher altitude forests are more accessible in PNG than in Papua. Mid-montane forests, being wetter than the lower montane forests, are probably more suitable for members of the genus.

The lowland tropical rain forest is diverse with many species of *Riedelia* including *R. albertisii*, *R. aurantiaca*, *R. brevicornu*, *R. erecta*, *R. geanthus*, *R. grandiligula, R. longifolia*, *R. macranthoides*, *R. maxima*, *R. nabirensis*, *R. pterocalyx*, *R. stricta*, *R. subulocalyx,* and *R. tenuifolia*.

As stated above, many species of *Riedelia* grow in the montane zone. Species have been subjectively allocated to a vegetation type based on the altitude of the collections. Due to the Massenerhebung effect resulting in vegetation zones being lower on smaller mountain masses, the simple use of altitude as a guide to the vegetation type has probably led to inaccuracies. The vegetation data on labels of collections of *Riedelia* is inadequate. Probably several of the 'lower montane' species will, with more detailed study, be placed as largely mid montane in their distribution ecology.

The following species of *Riedelia* have been recorded from the lower montane zone: *R. affinis*, *R. bicuspis*, *R. dolichopteron*, *R. decurva*, *R. ferruginea*, *R. fulgens*, *R. klossii*, *R. ligulata*, *R. longisepala*, *R. macrantha*, *R. monophylla*, *R. pulcherima*, *R. robusta*, *R. umbellata*, and *R. urceolata.*

The mid-montane forest is probably more diverse than the lower montane forest. Here, species of *Riedelia* include *R. arfakensis*, *R. bidentata*, *R. capillidens*, *R. geluense*, *R. hirtella*, *R. hagenii*, *R. monticola*, *R. orchioides*, *R. paniculata*, *R. purpurata, R. rosacea*, *R. schlechteri*, *R. sessilanthera, R. triciliata.*

The upper montane and subalpine forests are also diverse. Species of *Riedelia* known from these forests include *R. bidentata*, *R. curcumoidea*, *R. exalata*, *R. macrantha*, *R. marafungensis*, *R. microbotrya*, *R. montana*, *R. monticola, R. rosacea*, *R. suborbicularis*, and *R. subalpina.* The family is represented at its highest altitudes by *Riedelia montana* Valeton var. *montana* (Johns 2006), and by *Riedelia montana* Valeton var. *goliathensis* Valeton (Newman, in press).

The altitudinal database includes several problematic species too, which will require detailed study. Probably the species identifications are incorrect on herbarium sheets. These species include *Riedelia corallianae* (60-500 m and 1800-2250 m), *R. epiphytica* (40-1000 m and 2200-2750 m), *R. graminea* (250-900 m and 2400-3460 m), and *R. lanata* (10-90 m and 1500-1900 m). Another problematic species is *R. macrantha***,** which is collected over an altitudinal range from 10 to 3660 m.

8. Brief notes on other genera of Zingiberaceae in New Guinea

To recapitulate, the basic information on species number, number of collections (including collections not identified), percentage of endemism, and the distributions in Papua, Papua New Guinea and number of species recorded from both regions is given in Table 1. Notes are included only on the more poorly known genera. Several genera have many undescribed species in New Guinea.

Boesenbergia Kuntze is known from a single sheet from New Guinea collected in the Central Highlands of Papua New Guinea. *W. Vink 16553* was collected in secondary forest at 1960 m from the Minj-Nona Divide in the

Table 4. Altitudinal zonation of collections from herbarium specimens of selected genera of Zingiberaceae from New Guinea. Altitudinal Zones: 1. 0 – 499 m; 2. 500 – 999 m; 3. 1000 – 1499 m; 4. 1500 – 1999 m; 5. 2000 – 2499 m; 6. 2500 – 2999 m; 7. 3000 – 3499; 8. 3500 m+.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Alpinia	+	+	+	+	+	+	+	+
Amomum	+	+	-	-	-	-	-	-
Boesenbergia	-	-	-	-	-	+	-	-
Curcuma	+	+	+	-	-	-	-	-
Etlingera	+	+	+	+	-	-	+	-
Globba	+	-	-	-	-	-	-	-
Guillainia	-	+	-	-	-	-	-	-
Hedychium	+	-	-	-	-	-	-	-
Hornstedtia	+	+	+	+	-	-	-	-
Pleuranthodium	+	+	+	-	+	-	+	+
Riedelia	+	+	+	+	+	+	+	+
Thylacophora	+	-	-	-	-	-	-	-
Zingiber	+	-	-	-	-	-	-	-

Table 5. Altitudinal zonation of *Alpinia*, *Pleuranthodium*, and *Riedelia*. The number of collections is recorded for each altitude. (a) Collections with no recorded altitudes. Altitudinal Zones: 1. 0 – 499 m; 2. 500 – 999 m; 3. 1000 – 1499 m; 4. 1500 – 1999 m; 5. 2000 – 2499 m; 6. 2500 – 2999 m; 7. 3000 – 3499; 8. 3500 m+.

	a	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
All Zingiberaceae	599	392	96	125	180	124	93	46	6
Alpinia									
Papua	65	10	11	7	4	6	-	-	-
Papua New Guinea	82	24	12	2	2	4	-	4	1
Pleuranthodium									
Papua	13								
Papua New Guinea	28	5	1	1	-	1	-	3	1
Riedelia									
Maluku	7	14	2	1	-	-	-	-	-

highlands of Papua New Guinea. Vink noted it was planted but according to field notes 'it was not introduced by Europeans'. It was named Singa Manga in the Loowi Language of Papua New Guinea.

As presently known, *Pleuranthodium* is endemic to New Guinea, but collections from C Sulawesi and southern Philippines could extend its range. At present 22 species are known (Smith, 1991). Sixty three collections are entered in the database of which 11 have not been identified. All species are endemic. Only five endemics are known from Papua, fourteen from Papua New Guinea, and three species occur throughout New Guinea. With the exceptions of *Pleuranthodium piundaundensis* (P. Royen) R.M Sm., which has nine collections, all other species are known from only 1-4 collections.

Conclusions

There are many problems in the study of the Zingiberaceae in New Guinea. The family is very poorly collected from most areas in New Guinea; indeed, large areas are uncollected. As botanical explorations proceed we can expect a large increase in the number of species, as many appear quite local in distribution. The existing collections include over 1700 specimens of which 190 are only identified to family level. All the larger genera include significant numbers of specimens not identified at the species level.

Many duplicates of the *Riedelia* collections from the former German New Guinea were sent for study to Valeton in Bogor. Also, Herbarium Bogoriense has many duplicates of the *Riedelia* types based on the collections of Schlechter, which were described by Valeton. The problems encountered by many specialists working on the New Guinean flora, the destruction of critical types collections in Berlin, does not apply to this genus. Recent ginger specimens are often poorly collected, many in fruit but lacking flowers. The quality of the collections reflects the difficulties of collecting in New Guinea.

A detailed taxonomic understanding, particularly of *Riedelia* and *Alpinia*, will probably require the recollection (preferably from their type localities) of most New Guinea species. Many of the collections are poor (often due to insect damage in preservation) and have not been, probably cannot be, identified at the level of genus and species.

The major requirements for collecting specimens of gingers are outlined by Burtt and Smith (1976). Particular care should be made when collecting the flowers of gingers. Spirit material and materials for DNA studies could prove critical for an understanding of the larger genera in New Guinea. Photographs of the plants and flower details will be critical. The careful recording of ecological data is important. Future work should

also include living plant collections for growing in the botanic gardens at Lae and Bogor, with duplicate plants sent to Singapore and Edinburgh for additional planting, provided proper export permits are obtained.

No revision of the genera of the Zingiberaceae of New Guinea should be attempted until a sustained effort has been made to recollect adequate materials of the species from the type localities in order that the many names can be properly applied. This applies not only to *Riedelia* but to all the New Guinea genera of Zingiberaceae. Areas where the family is not, or is under collected, should also be targeted for future expeditions. Copies of the New Guinea database of the Zingiberaceae have been given to National Herbarium in Lae, the Singapore Herbarium, and the Herbarium of the Royal Botanic Gardens in Edinburgh.

Acknowledgements

I am very grateful to the Christensen Fund who provided a grant for studies on the flora of New Guinea. Without this support the studies would not be possible. I wish to express my sincere thanks to Dr. Jana Leong-Skornickova (SING) who encouraged my interests in the Zingiberaceae while working on the New Guinea database at the Singapore Botanic Gardens. Thanks are due to the Directors of the following Herbaria for permission to examine their collections: BO, BRI, CANB, LAE, SING. I also wish to thank to Dr. Mark Newman (E) for sending me a copy of his unpublished paper on the Zingiberaceae prepared for the 'Ecology of Papua', and also to thank the two reviewers for their constructive comments.

References

Burtt, B.L. and R.M. Smith. 1972a. Key species in the taxonomic history of Zingiberaceae. *Notes from the Royal Botanic Garden, Edinburgh* **31**: 177–227.

Burtt, B.L. and R.M. Smith. 1972b. Notes on Malesian Zingiberaceae. *Notes from the Royal Botanic Garden, Edinburgh* **31**: 307–316.

Burtt, B.L. and R.M. Smith. 1976. Notes on the collection of Zingiberaceae. *Flora Malesiana Bulletin* **29**: 2599–2601.

Gilli, A. 1980 [publ.1983]. Beiträge zur Flora von Papue-New Guinea, III Monocotyledones. *Annalen des Naturhistorischen Museums in Wien,* B, **84**: 5-47.

Johns, R.J., P.J. Edwards, T.M.A. Utteridge and H.C.F. Hopkins. 2006. A guide to the alpine and subalpine flora of Mount Jaya. Kew Publishing, Royal Botanic Gardens, Kew.

Larsen, K., J.M. Lock, H. Maas and P.M. Maas. 1998. Zingiberaceae, pp. 474-495. In: Kubizki, K. (ed.): *The Families and Genera of Vascular Plants,* Vol. IV. Springer-Verlag, Berlin, Heidelberg.

Loesener, T. 1930. Zingiberaceae. *Die Natürlichen Pflanzenfamilien* (2nd ed.) **15a**: 541-640, 654-693.

Newman, M.F. 2007. Zingiberaceae. pp. 473-476 In: A.J. Marshall and B. Beehler (eds.). *The Ecology of Papua*. 5. Periplus (HK) Ltd Editions, Singapore.

Newman, M., A. Lhuillier and A.D. Poulsen. 2004. Checklist of the Zingiberaceae of Malesia. *Blumea Supplement* **16**: 1–166.

Rickett, H.W. and F.A. Stafleu. 1959. Nomina generica conservanda et rejicenda spermatophytorum. *Taxon* **8**: 213-243.

Ridley, H.N. 1886. New species collected by Forbes. *Journal of Botany* **24**: 356-358.

Ridley, H.N. 1916. Report of the Botany of the Wollaston Expedition to Dutch New Guinea 1912-1913. *Transactions of the Linnean Society, Botany* **9**: 1–269.

Ridley, H.N. 1923. A contribution to our knowledge of the Flora of Papua (British New Guinea). *Proceedings of the Royal Society, Queensland* **34**: 19-21.

Riswan, S. and F.M. Setyowati. 1996. Ethnobotanical study of Zingiberaceae in Indonesia, pp. 196-218. In: Wu, T.L., Wu, Q.G. & Chen, Z.Y. (eds.). *Proceedings of the 2nd Symposium on the Family Zingiberaceae*. Zhongshan University Press.

Royen, P. van 1979. Zingiberaceae. In: *The Alpine Flora of New Guinea* **2**: 860-866.

Schumann, K. 1899. Monographie der Zingiberaceae von Malaisien und Papuasien. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **27**: 259–350, t. 2–6.

Schumann, K. 1904. Zingiberaceae. In Engler, A. & Prantl (eds.), *Das Pflanzenreich* IV, **46 (20)**: 1–458, figs. 1–52.

Smith, R.M. 1975. A preliminary review of the large bracteate species of *Alpinia*. *Notes from the Royal Botanic Garden, Edinburgh* **34**: 149–182.

Smith, R.M. 1990a. *Alpinia* (Zingiberaceae): a proposed new infrageneric classification. *Edinburgh Journal of Botany* **47**: 1–75.

Smith, R.M. 1990b. *Psychanthus* (K. Schum.) Ridley (Zingiberaceae): its acceptance at generic level. *Edinburgh Journal of Botany* **47**: 77–82.

Smith, R.M. 1990c. *Pleuranthodium* replaces the illegitimate name *Psychanthus* (Zingiberaceae). *Edinburgh Journal of Botany* **48**: 63–68.

Valeton, T. 1913a. Zingiberaceae. *Icones Bogoriensis* **4(3)**: t. 373-375.

Valeton, T. 1913b. Zingiberaceae. *Nova Guinea* **8**: 923–988, t. 162–179.

Valeton, T. 1914. Die Zingiberaceen Deutsch-Neu-Guineas. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **52**: 41–100, figs. 1–11.

Valeton, T. 1917. Zingiberaceae. In: Gibbs, L.S., *A Contribution to the Phytogeography and Flora of the Arfak Mountains*. Taylor & Francis, London.