

A PRELIMINARY SURVEY OF THE PANDANACEAE OF THAILAND AND CAMBODIA

by

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ABSTRACT

Of the family Pandanaceae (Angiospermae, Monocotyledonae), two genera and some 26 species have hitherto been reported to occur in Thailand. Of these, two are species of *Freycinetia*, the rest are of *Pandanus*. This survey reduces the number somewhat but also adds some new species to the flora, of which none are new to science. Two species of *Freycinetia* and 24 species of *Pandanus* are credited to the Thai flora, based on a study of the herbarium materials in Bangkok and Malaya, and on earlier published records. One *Freycinetia* and five *Pandanus* species are definitely reported from Cambodia, but others may also occur. Some critical notes are given for several species and for the Sections Rykia, Solmsia, and Hombronia of *Pandanus*.

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I. HISTORICAL AND GENERAL INTRODUCTION

The first definite record of a member of the family Pandanaceae from Thailand seems to be a collection of *Pandanus kaida*, collected by the Dutch botanist J.E. Teijsmann, who made a brief botanical trip to Siam in the middle of the 19th century (TEIJSMANN, 1863). The specimen is in Bogor, if also in Leiden, I have not been able to locate it. At any rate this seems to be one of the very few correctly identified species of the family to be reported from Thailand up till recently. Thereafter, a blank period ensues, until the publication of F.N. Williams' "Liste des plantes connues du Siam" (1904-05). Williams described what he thought was a new *Pandanus* (*P. siamensis*) but this is only a renaming of *P. kaida*, which is probably the most common, even ubiquitous, and ought presumably to be one of the best-known, of pandans in the whole of S.E. Asia. On the contrary, this species—which is everywhere cultivated, in villages and in rice-fields, and even in the cities—is scarcely mentioned in the botanical literature after Kurz (1869), who named the species. It is not mentioned by Hooker, in the *Flora of British India* (HOOKER, 1894); nor by Ridley, in the *Flora of the Malayan Peninsula* (RIDLEY, 1925); nor by Martelli in *Flore Generale de l'Indo-Chine* (MARTELLI, in LECOMTE, 1937); yet it is a very important species cultivated in all the regions these works purport to cover. If, as I suspect, the name *Pandanus forceps* Martelli is a synonym, then this same plant occurs in Yunnan Province, S. China, and perhaps also in Canton and Hong Kong. A full discussion and description of this species, with illustrations, has recently been published by the present author (STONE 1970).

Johannes Schmidt collected a pandan in Koh Chang which was later identified as *P. tectorius* var. *sinensis* Warb. by C.H. Ostenfeld in Schmidt's "Flora of Koh Chang" (OSTENFELD in SCHMIDT, 1901-16). Ostenfeld's determination was correct, but the name of this plant is now considered to be *P. odoratissimus*, while *P. tectorius* is a similar, closely related, but distinct species of Eastern Indonesia and the Pacific Islands (STONE 1967).

Count Martelli described two species relevant to our present discussion one of which (*P. capusti*) was described from Vietnamese materials and which is herein first recorded for Thailand; it also occurs in Cambodia, where it has been called *P. pendens*. The other species

(*P. pierrei*) is here reduced to *P. ovatus*, a Malayan species. Martelli also proposed some further Indochinese species which (as he mentions in 1914) were to be published in his treatment of the family for LeComte's "Flore Generale de l'Indo-Chine"—but this treatment was not published for another 23 years, after Martelli's death (MARTELLI in LE COMTE, 1937). In this work there are several references to Cambodia but nothing of importance concerning Thailand. However Martelli first reported *Freycinetia* from both Cambodia and Vietnam, though he was unable to identify the species. (It has since been found to be *F. sumatrana*, which also occurs in Thailand; cf. STONE and ST. JOHN, 1969).

W.G. Craib described two new species of *Pandanus* from Thailand, *P. distans* and *P. similis*. As will be explained below, these names are apparently synonyms of earlier described species. (Cf. CRAIB 1912).

Some mention must be made of H.N. Ridley's work on the Malayan flora. The basis of this, his "Materials for a Flora of the Malayan Peninsula" (RIDLEY, 1907), was reprinted almost verbatim, somewhat shortened, in his "Flora of the Malay Peninsula" (RIDLEY, 1925). Ridley often included south Siamese plants, especially those from Satun, Pattani, or the islands immediately north of Pulau Langkawi, which are now part of Thailand. He also published some papers on this area, in which some brief references to pandans may be found.

In 1961 Smitinand reported a Thai *Pandanus* which he identified as *P. thwaitesii* Martelli; but further study of this shows that it is not that Ceylonese species.

Nearly all the more important publications on *Pandanus* in this region are by Prof. H. St. John of the Bishop Museum in Honolulu. He has proposed a fair number of new species for the floras of Thailand, Malaya, Cambodia, and Vietnam, in *Pacific Science* (1960-1970 and continuing), all of which have some bearing, directly or indirectly, on the present survey. Prof. St. John's concept of species is a very narrow one, and as a result a rather large number of synonyms have been created, as well as species which, if really distinct, are very difficult to characterize. This problem has already been discussed in some detail (STONE, 1967 a). In some cases inadequate or misleading comparisons, erroneous statements of relationship, and absence of data concerning

earlier described but still imperfectly known species, introduce confusion and impose on the reader many difficulties in using the information provided, valuable as this in itself may be. Since no keys are given and almost no references to earlier work, these studies have I think to be viewed skeptically and only provisionally accepted. When further explorations and collections are made, as they clearly must be, these ostensibly new taxa can be more effectively evaluated, and important ancillary data, such as habitat ecology, can be discovered.

A few years ago the present writer tried to summarize the then existing information on *Pandanus* in Malaya, Singapore, and lower Thailand (STONE, 1966-68). By lower Thailand was intended only the area immediately adjacent to the present Malaysian border, where Ridley had reported a few species, or in other words, nothing farther north than Phuket. More recently, the species of *Freycinetia* in this same region have been reported (STONE 1970 b), and this paper gives what is evidently the first clear identification of the two species of *Freycinetia* which occur in Thailand. Of these one also occurs in Cambodia and Vietnam, and with another species still known only from Vietnam, was recently discussed by STONE and ST. JOHN (1970).

The present survey is intended mainly to bring together the relevant earlier work, to evaluate this insofar as is possible, and to report on the existing herbarium materials in Bangkok (at the Forest Herbarium, BKF, and the Agriculture Dept. Herbarium, BK). However earlier studies by the the writer in other herbaria, chiefly Singapore, Bogor, Kew, Kepong, Leiden, and Kuala Lumpur have been of great value and are mentioned below when necessary. To the curators and directors of these institutions, particularly Tem Smitinand and Miss Umpai Yongbunkird, the writer is greatly indebted for courtesies and assistance rendered.

II. SYSTEMATIC TREATMENT

PANDANACEAE

A family of 3 genera, *Sararanga* Hemsl. (limited to the Solomon Islands, New Guinea, and the Philippines), *Pandanus*, and *Freycinetia*. The last comprehensive treatment of the family is that of WARBURG (1900) which is now hopelessly outdated and chiefly of historical interest. *Pandanus* has certainly more than 500 species, *Freycinetia* nearly 200. The former is paleo-tropical, extending from West Africa to Polynesia; the latter has a more restricted range, and reaches from Ceylon (not India) to Polynesia.

The only relevant regional treatments are those of RIDLEY for Malaya (1925), MARTELLI for Indo-China (1937) and STONE, for Malaya again (1966-68). Much earlier and now quite useless treatments include those by HOOKER *fil.* (1894) and KURZ (1867, 1869, 1877), though again these have some historical interest. None of these, including my own paper, is complete, and Thailand and Cambodia are scarcely mentioned. The "Florae Siamensis Enumeratio" of CRAIB never reached this family.

Key to the genera

Trees, shrubs, or subshrubs, never climbers (though rarely epiphytic); carpels 1-ovulate, endocarp thick bony; filaments microscopically smooth and epapillose. *Pandanus*

Woody climbers; carpels many-ovulate, endocarp membranous; filaments microscopically papillose. *Freycinetia*

(A) *PANDANUS* L. ap. Stickm.

A very large genus, fairly well-represented in Thailand, less so (apparently) in Cambodia. Of the more than 30 sections (infrageneric taxa) of the genus, six certainly occur in Thailand, and a seventh, known in Tenasserim (Burma) may also. This last is included in the key.

Of the woody arborescent monocots this is one of the most important genera. Unlike some (*Dracaena*, *Puya*) this genus is incapable of incremental lateral growth as it lacks any cambial activity. Habit varies considerably nonetheless, from nearly herbaceous subshrubs such as *P. toei*, to massive stemless plants with underground rhizomes (such as *P. biplicatus*), to small shrubs with prostrate or decumbent stems, large shrubs with or without well-developed aerial proproots, and large trees (to 100 ft. tall in some New Guinea species). The smallest species in Thailand is perhaps *P. toei*, and the largest may be *P. unicornutus*.

**Key to the Sections of Pandanus occurring
in Thailand and Cambodia**

(For a fuller discussion of sections, cf. STONE 1966).

See Figs. 1-5.

1. Leaf apex with prickles on the two lateral ventral pleats (See Fig. 1a).
Fruits composed of 1-celled drupes. Stamens simple, free.
 2. Style simple, the stigmatic surface dorsal, linear-lanceolate or ovate-deltoid. (See Fig. 2a).
 3. Mostly shrubs or trees, rarely acaulescent; styles slender spine-like, stigmatic surface nearly linear, grooved; leaves not especially dark or rigid. (I) Sect. *Acrostigma*
 - 3 Mostly acaulescent and soboliferous; style beak-like, with ovate-deltoid stigmatic surface; leaves exceptionally dark and rigid. (II) Sect. *Fusiforma*
 - 2 Style toothed, stigmatic surface ventral, rather broad. Rheophyte shrubs. (See Fig. 2b). (VII) Sect. *Asterostigma*
1. Leaf apex with smooth unarmed lateral ventral pleats (See Fig. 1b).
Fruits composed of 1-celled drupes or of phalanges of several fused carpels. Stamens connate in phalanges with a common column (stemonophore).
 4. Leaves (dried) not usually or conspicuously reticulate-veined; leaf teeth green to white, usually not purplish; fruits composed of several-celled syncarps called phalanges, each of the carpels tipped by an ovate or reniform stigma. Stamens racemosely arranged on the stemonophore. (See Fig. 3a). (III) Sect. *Pandanus*
 - 4 Not with the above character combination.
 5. Leaves (dried) often rather strongly reticulate-veined (See Fig. 4); leaf-teeth and leaf-bases often coppery or purplish; fruits composed of 1-celled drupes, or these mingled with a few 2-4-celled phalanges; styles spine-like or beak-like, often some or all of them forked (See Fig. 3b). (IV) Sect. *Rykia*

- 5 Leaves not or but obscurely reticulate; fruits composed of 1-few-celled drupes, but all styles simple, spiniform or beaklike, not forked.
6. Drupes slender fusiform to narrowly obovoid or obclavate, style spiniform, very slender, caducous. Aquatic or swamp plants. Stamens peltate from edge of a disc terminating the stemonophore. (See Fig. 5a). (V) Sect. *Solmsia*
- 6 Drupes plump, rather large, broadly ellipsoid to obovoid, apical mesocarp copiously pithy; style large, broad, deltoid. In our area mostly plants of limestone hills or maritime. Stamens racemosely arranged on the stemonophore. (See Fig. 5b). (VI) Sect. *Hombronia*

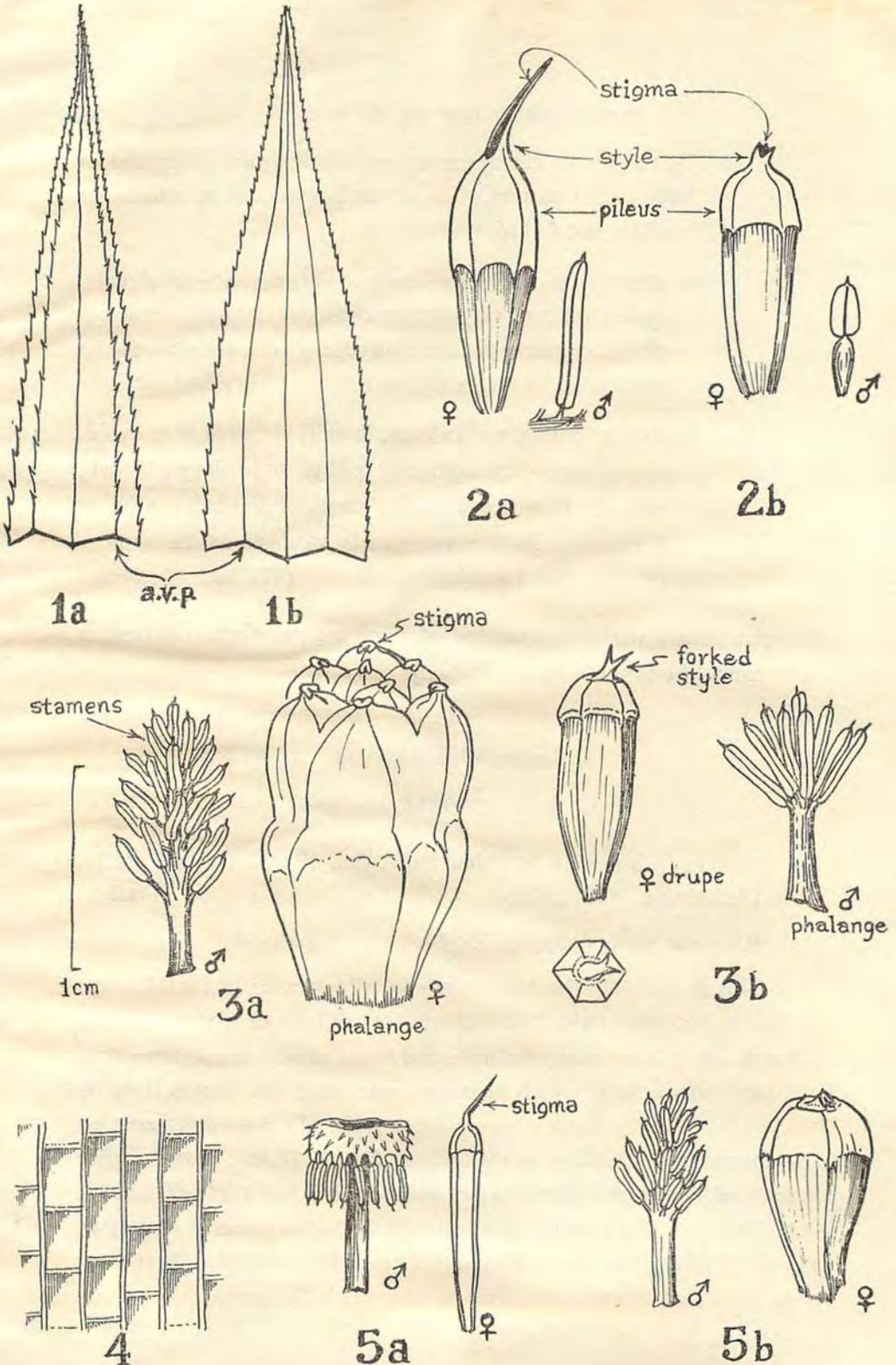
[See also *P. amaryllifolius* at the end of this paper; a sterile cultivar, it cannot be assigned to any Section].

Enumeration of species

I. Sect. *ACROSTIGMA* Kurz

- (1) *Pandanus recurvatus* St. John, Pacif. Sci. 19: 227, figs. 220-221. 1965. Stone, 1965: 210. [Plate I.]
P. ornatus, sensu Ridley, 1925: 80.

This is probably the most common wild species in the Malayan peninsula, occurring from a few hundred feet altitude, or less, up to about 4,500 ft. It is fairly easily distinguished by its slender, erect stems, long and very narrow leaves with glaucous undersides, and particularly by the pendulous, cylindrical, glaucous-green fruit. St. John first reported this species from Thailand on the basis of *Kerr 7191*, but he had earlier indentified this same specimen as *P. monothea* Martelli (in Pacif. Sci. 17: 468, 1963). A study of this specimens (in BK) shows clearly that it is, indeed, *P. recurvatus*. It, and two other specimens cited here for the first time, show that this species occurs in Peninsular Thailand.



Figs. 1-5. Showing characteristic parts of *Pandanus*. — 1. Leaf apex. 2. Stamens and drupes of Sections *Acrostigma*, *Fusiform* (a), and *Asterostigma* (b). 3. Stemonophores and drupes of the Section *Pandanus* (a), and *Rykia* (b). 4. Leaf venation. 5. Stemonophores and drupes of the Section *Solmsia* (a), and *Hombroma*.

THAILAND: Peninsular; Narathiwat, Sungai Padi, Chat Warin Falls, 50 m. altitude, 15-6-1970, *Smitinand 10,969* ♀ (BKF).—Bacho, 25-5-1961, *B. Sangkhachand 173* ♀ (BKF!).—Pattani, Bachaw, 600 m. alt., 14-7-1923, *Kerr 7191* ♀ (BM! BK!).

- (2) *Pandanus ovatus* Warb., Pflanzenr. 3, IV. 9: 80-81. 1900. St. John, Pacif. Sci. 19: 231, f. 222. 1965. [Plates II, III, IV.]

Synonymy: *P. pierrei* Martelli var. *Bariensis* Martelli, Bull. Soc. Bot. Ital. (1903): 303. 1904—*P. distans* Craib, Kew Bull. 1912: 417. *P. toinu* St. John, Pacif. Sci. 19: 526, f. 227. 1965.—*P. retroaculeatus* St. John, Pacif. Sci. 19: 524, f. 226. 1965. ? *P. similis* Craib, Kew Bull. 1912: 417.

All the synonyms given above are names of plants which, it seems to me, differ in no significant details from *Fisquetia ovata* Gaudich., the type of *P. ovatus* Warb. An excellent illustration is provided by St. John. His species *P. toinu* and *P. retroaculeatus* are based on specimens with very immature fruits, hence their dimensions are misleading. The difference in prickle size (particularly on the midrib) is more striking but does not appear to warrant the distinction of more than one species.

Craib has as distinguishing features for his *P. distans* the occurrence of two cephalia on a single peduncle ("*syncarpis duobus spicatis*") and their wide separation ("*distantibus, haud ad pedunculi apicem confertis* . . .") but three other infructescences on the same type sheet (see Plate II) have solitary cephalia, which shows how unreliable this character is. Furthermore, in my collections from Mt. Kam Chay, Bokor, Cambodia (cited below), some inflorescences were of one head, others of two or even three. The same phenomenon occurs in other species, e.g. *P. kaida*, *P. penangensis*. Craib's *P. distans* is also rather strongly reminiscent of *P. perakensis* Ridl., a Malayan species known from Perak, Kedah, and Pahang; but in this the leaves seem consistently larger, and it may be distinct; it is much like *P. aurantiacus* Ridl. (which is the same as *P. affinis* Kurz and probably also *P. leucocephalus* Gagnep. ex Martelli, the latter being an invalid name).

P. pierrei was based on several Vietnamese and Cambodian collections, including plants from Baria and Bokor, which later were

named var. *bariensis*. My collections from this latter locality are therefore presumably authentic representatives of the variety (at least), and since only one other species occurs on Mt. Kam Chay (*P. cupribasalis*) the possibility of confusion with some similar species can be discounted. The var. *pierrei*, however, appears to have larger dimensions throughout, and perhaps is a distinct species; at any rate it appears to occur only in Vietnam. I have not much doubt that these plants are the same as *P. ovatus*.

Incidentally, Ridley included *P. elostigma* Martelli as a synonym of *P. ovatus*, but I can vouch for the distinctness of that species, supporting St. John's acceptance. It could possibly also occur in Thailand, although all the known specimens to date are from Malaya (chiefly Perak and Pahang).

I am not sure about *P. similis* Craib; it may yet prove distinct.

THAILAND: Northern; Hue Me Sakawn, between Phrae and Nan, 420 m. alt., *Kerr 2386* ♀ (type of *P. distans*, in K! photo in BKF!), Muang Pong, N.W. of Nan, 300 m., 14-3-1921, *Kerr 5078* (BK!). Eastern; Katok, Korat, 29-12-1923, *Kerr 8159* (BK!). Central; N. Saraburi, June 1960, *St. John 26,361* ♀ (BKF!); Nakhon Nayok, Khao Yai National Park, 800 m. alt., 24-5-1970, *Smitinand 10,896* ♂ (BKF!). Southeastern; Prachin Buri, waterfall, 14-11-1964, *Sakol 121* ♀ (BK!). Peninsular; Phang-Nga, between Thai Muang and Thai Hat, 50 m., 24-5-1960, *Smitinand 6596* ♀ (BKF! 2 sheets). Ronphibun Hill, Nakhon Si Thammarat, 2000 ft. alt., *Eryl Smith 485* ♀ (BK! type of *P. retroaculeatus*)

CAMBODIA: Chaîne de l'Éléphant, Mt. Kam Chay above Bokor, March 1970, 100-1000 m. alt., *Stone 9314* ♀ *9280* ♂ (KLU!).

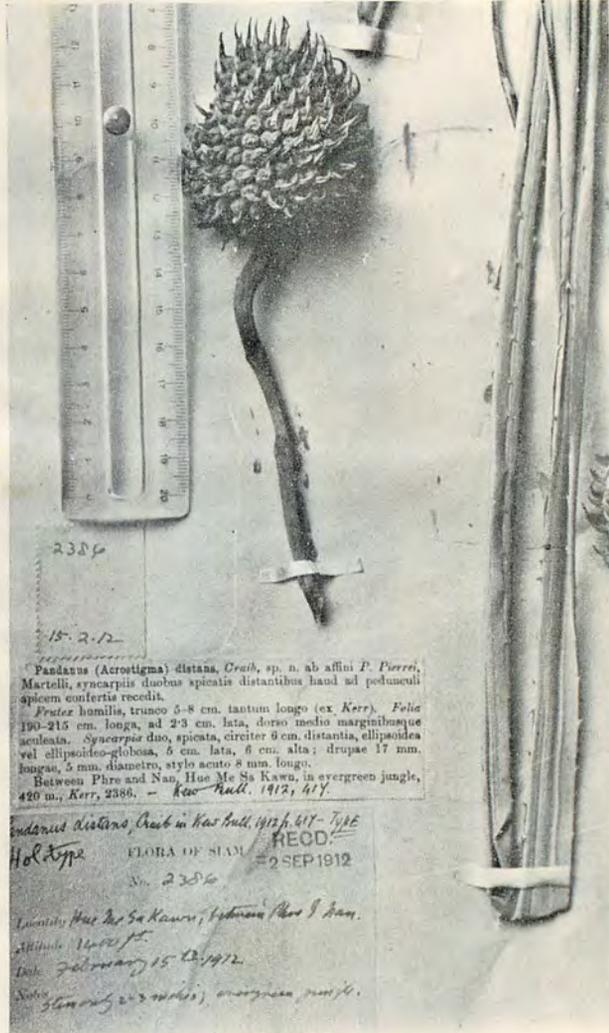
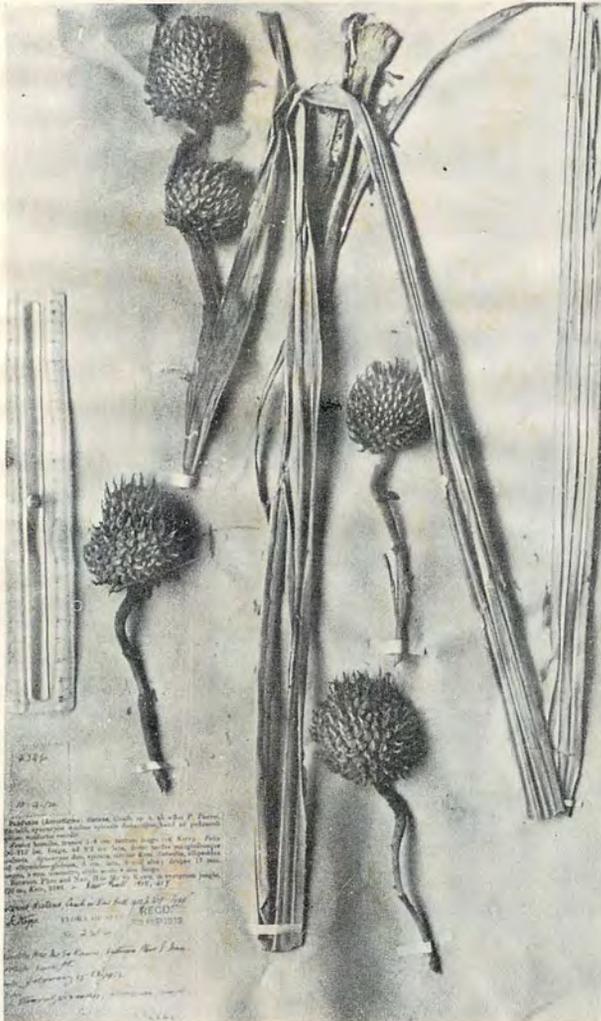
(3) *Pandanus toei* St. John, *Pacif. Sci.* 17: 468, figs. 193-194. 1963.

[Plate V.]

I am tentatively accepting this species, which seems to differ from *P. ovatus* in its more softly herbaceous leaves, which are paler green but not glaucous on the undersurfaces, and by the styles which radiate from the cephalium stiffly and are not upcurved. In this latter character the species resembles *P. elostigma* Martelli, but that differs in its much more rigid darker leaves with very distinctly zonate glaucous under-surfaces,



P. recurvatus St. John (Smitinand 10969).



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15. 2. 12
Pandanus (Acrostigma) distans, Craib, sp. n. ab affini *P. Pierrei*, Martelli, syncarpis duobus spicatis distantibus haud ad pedunculum spicam confertis recedit.
Frutex humilis, truncus 5-8 cm. tantum longo (ex Kerr). Folia 190-215 cm. longa, ad 2.3 cm. lata, dorso medio marginibusque aculeata. Syncarpia duo, spicata, circiter 6 cm. distantia, ellipsoidea vel ellipsoideo-globosa, 6 cm. lata, 6 cm. alta; drupae 17 mm. longae, 5 mm. diametro, stylo acuto 8 mm. longo.
Between Phre and Nam, Hue Me Sa Kawa, in evergreen jungle, 420 m., Kerr, 2386. - *Kew Bull.* 1912, 417.

Pandanus distans, Craib in *Nat. Bull.* 1912, p. 417. Type
Holotype FLORA OF SIAM RECD. 2 SEP 1912
No. 2386
Locality Hue Me Sa Kawa, between Phre & Nam.
Attitude 420 ft.
Date February 15, 1912.
Duke (stem only 203 m. high), evergreen jungle.

Pandanus ovatus warb. (type of *P. distans* Craib), Kerr 2386.

and its acaulescent habit. Plants which were affirmed to belong to *P. toei* are in cultivation in front of the Forest Herbarium (they appear to be males). In appearance these do not show the short but well-developed stems of *P. ovatus*. St. John cites quite a few specimens from Thailand, mainly from the peninsular or south-eastern parts, and also some from Malaya; but these latter (CURTIS 1821 and RIDLEY in Oct. 1904) do not appear to be of the same species, but rather of *P. ovatus*. The species are similar and especially from scrappy herbarium materials are difficult to distinguish, but in nature they would seem to be reasonably discriminated.

This species might be expected to occur in Cambodia; as yet however there are no definite records.

(4) *Pandanus* sp. *ignot.* (H.S.S. 11200).

THAILAND; Northern; Khao Huey Khae, alt. 830 m., 21-2-1964, B. Hansen. G. Seidenfaden, and T. Smitinand 11,200 (BKF!).

An acaulescent plant with the leaves rather reticulated toward the apex, the midrib teeth projecting at right angles and 2.5 mm long, the apical ventral lateral pleats minutely prickly, the fruit dark green and globular.

This specimen, which seems to represent a fourth species of Sect. *Acrostigma* in Thailand, and another specimen (no. 11,975) which is probably the same species, cannot be reconciled as yet with earlier known species. It may be undescribed. Fruits, however, are lacking in BKF! and so no further description seems warranted at this time.

II. Sect. *FUSIFORMA* St. John

Two Thai species pertain to this section, though neither was originally assigned to Sect. *Fusiforma*. Previously in *Reinwardtia* (STONE 1967), I reviewed this section and transferred these species to *Fusiforma*, on the basis of the descriptions and illustrations. It is satisfying to find by examination of the types that the specimens completely support this conclusion.

Sect. *Fusiforma* consists of a small number of closely related species found only in Malaya, Borneo, and S. Thailand. It is very closely related

to Sect. *Acrostigma*, and perhaps might be considered only a group in that section; but, although sharing a number of critical characters, Sect. *Fusifforma* also appears to be well enough distinguished by the following features; acaulescent, soboliferous habit; very dark, very rigid leaves; styles beaklike; stigmatic surfaces ovate-deltoid.

No further collections of the two Thai members of the Section have been found.

- (1) *Pandanus biplicatus* St. John, *Pacif. Sci.* 17: 466, fig. 192. 1963.
Stone 1968: 412.

Type: *Haniff & Nur 2703* (SING), from Janjau, Kopah, 9-12-1917.

Still known only from the type. This plant was, not unreasonably, at first assigned to Sect. *Acrostigma* by St. John.

- (2) *Pandanus magnifibrosus* St. John, *Pacif. Sci.* 17: 478. f. 198. 1963.
Stone 1968: 412.

Type: *Kerr 19,227* (BK!), Kao Soi Dao, Patalung, Peninsular Thailand.

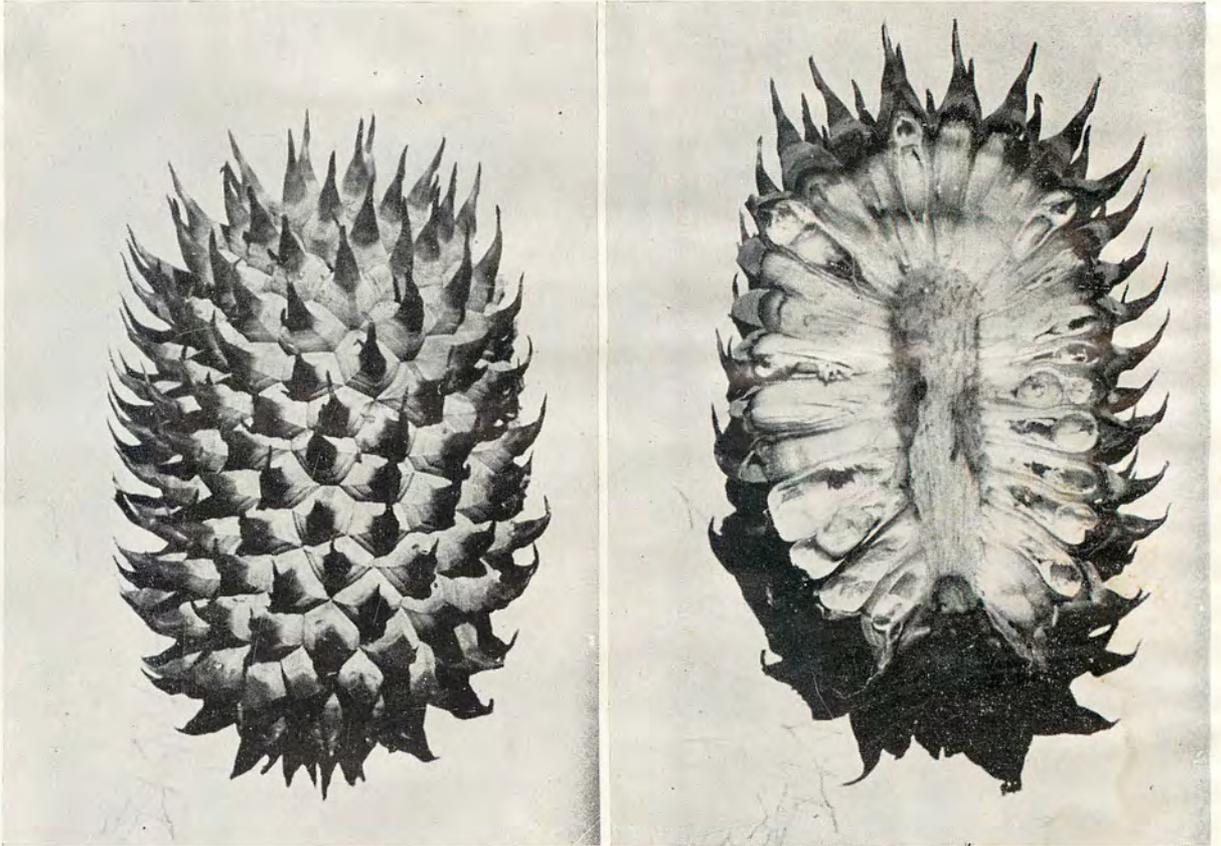
Still known only from the type.

This plant was, strangely enough, assigned to Sect. *Rykia*, an error attributable no doubt to the fact that the drupes have been cut away from what must have been a globular cephalium, but without indication of their orientation. Thus it is impossible to tell whether the stigmatic surfaces are dorsal or ventral. However, the very conspicuous prickles on the apical ventral pleats of the leaves afford distinct evidence that the plant cannot be a *Rykia*, which section is always characterized by the unarmed lateral ventral pleats.

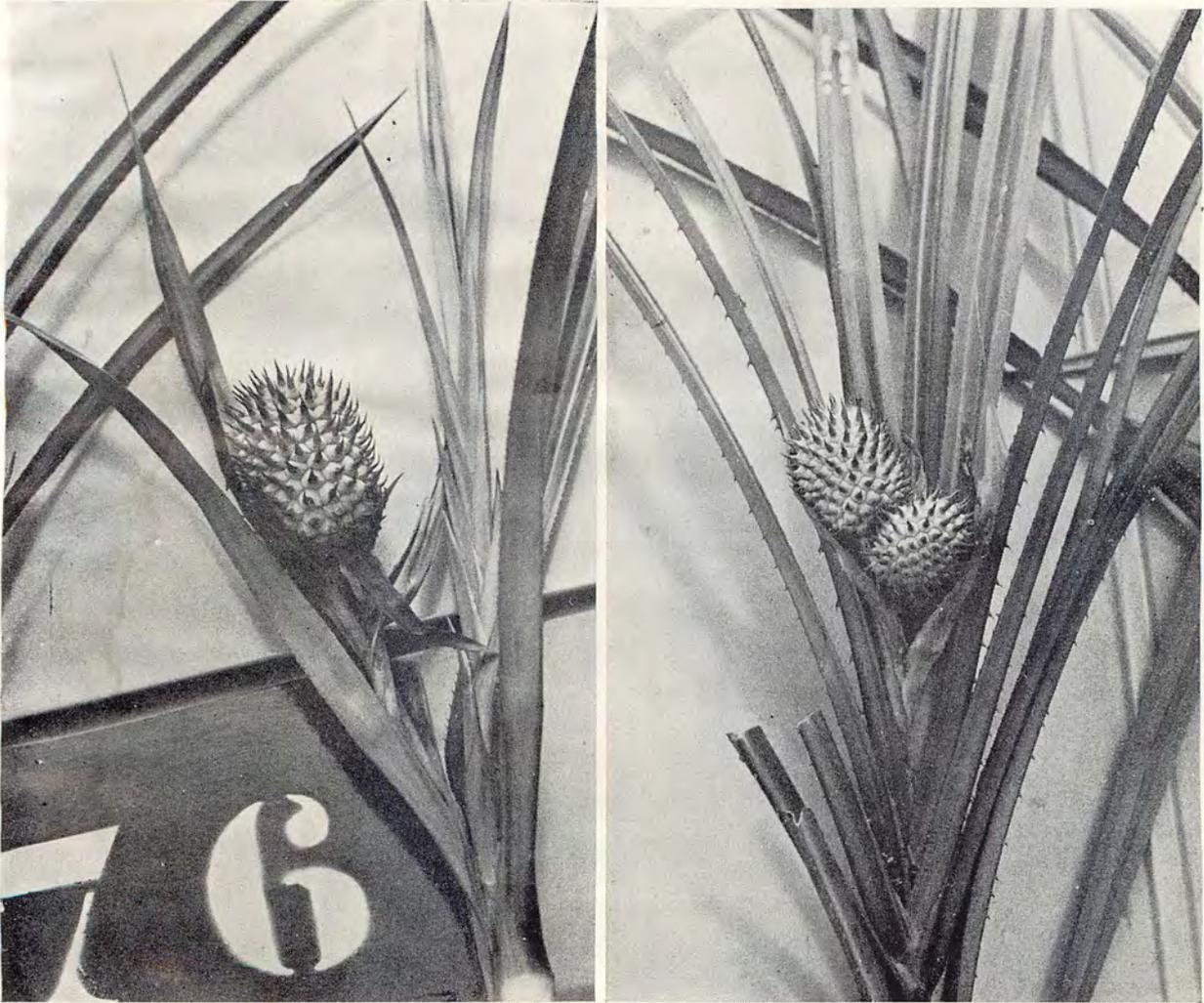
To distinguish *P. magnifibrosus* from *P. biplicatus*, recourse may be had to the comparative size and spacing of the leaf prickles, which in the former species are larger and more remote along the leaf apex.

Prickles of ventral pleats 0.2-0.3 mm long, 1-4 mm
apart. *biplicatus*

Prickles of ventral pleats 0.5-0.8 mm long, 3-8 mm
apart. *magnifibrosus*.



P. ovatus Warb. (*P. pierrei* var. *bariensis* Martelli) BCS. 9314.



P. ovatus. Warb. (BCS. 9314).

III. Sect. *PANDANUS*

This section, which includes the type of the genus, *P. odoratissimus*, is represented in our area by three species, all of which are cultivated, but one is usually a wild plant, and the second seemingly sometimes naturalized. The third is a normally sterile cultivar found only in cultivation.

The taxonomy of this section has been clouded by the descriptions of very many new species with almost no real distinguishing features. I have commented on these at some length in another paper (STONE 1967), and here adopt the same rather conservative point of view. Unquestionably there is a good deal of variability in *P. odoratissimus*, but my impression is that this has nothing to do with species distinctness; rather, it is a matter of individuals, of environmental effects, of stages of growth, and often enough, of mere herbarium artefacts... I have no doubt whatsoever about the conspecificity of the specimens cited.

Plants of this section are the ones most likely to be familiar to the non-specialist, as they include the commonest and most easily observed species. Since both *P. kaida* and *P. tectorius* (*P. sanderi*, etc.) are often found within cities and towns, they often form an 'introduction' to the genus.

Key to species

1. Leaves rather fiercely armed with large white prickles (sometimes almost 10 mm long), leaf undersurfaces with two prominent glaucous strips; upper surface also sometimes glaucous; blades often rather strongly twisted. Fruits almost always solitary, more or less globular, ripening vermilion-red or bright orange; phalanges with conspicuous fleshy 'shoulders' (though these are not evident except at full ripeness and are subject to great shrinkage on drying). Staminate inflorescences with cream-white bracts, strongly sweet-scented. Usually wild plants on sandy beaches, but occasionally found inland and in cultivation. Phalanges mostly 5-15-celled.

P. odoratissimus

1. Leaves moderately armed with smaller greenish or pale prickles, rarely over 6 mm long; lower surface only slightly or not glaucous; blades not very strongly twisted (or scarcely at all). Fruits either solitary or racemose. Usually cultivated.
2. Fruits solitary or spicate, up to 7 together; phalanges mostly 1-4-celled. Leaf prickles up to 5-6 mm long. Very abundant in rice-fields and in villages. *P. kaida*
2. Fruits usually solitary (but very rarely produced in cultivated specimens); phalanges mostly 5-15-celled, without or with small shoulders. Leaf prickles rarely over 3 mm long, mostly greenish, sometimes absent. Leaves sometimes variegated with green or whitish bands (*P. sanderi*, *P. veitchii*, *P. baptisti*). Cultivated, mainly in towns and cities (?). *P. tectorius*
various cultivars.

- (1) ***Pandanus odoratissimus*** L.f. Suppl. 424. 1781. Stone 1967: 236, figs. 1-6. [Plate VI-A]

P. tectorius var. *sinensis* Warb. Pflanzenr. 3. IV. 9: 1900.

P. fascicularis Lamarck, Encycl. 372. 1810.

P. verus Kurz, J. Bot. 5: 125. 1867.

P. leucacanthus Hasskarl, Flora 2, Beibl. 14. 1842.

P. tectorius, sensu Martelli, in part, Webbia 4; 1913.

?*P. odorifer* (Forssk.) O. Kuntze, Rev. Gen. 2: 737. 1891.

(For numerous other synonyms cf. STONE, 1967).

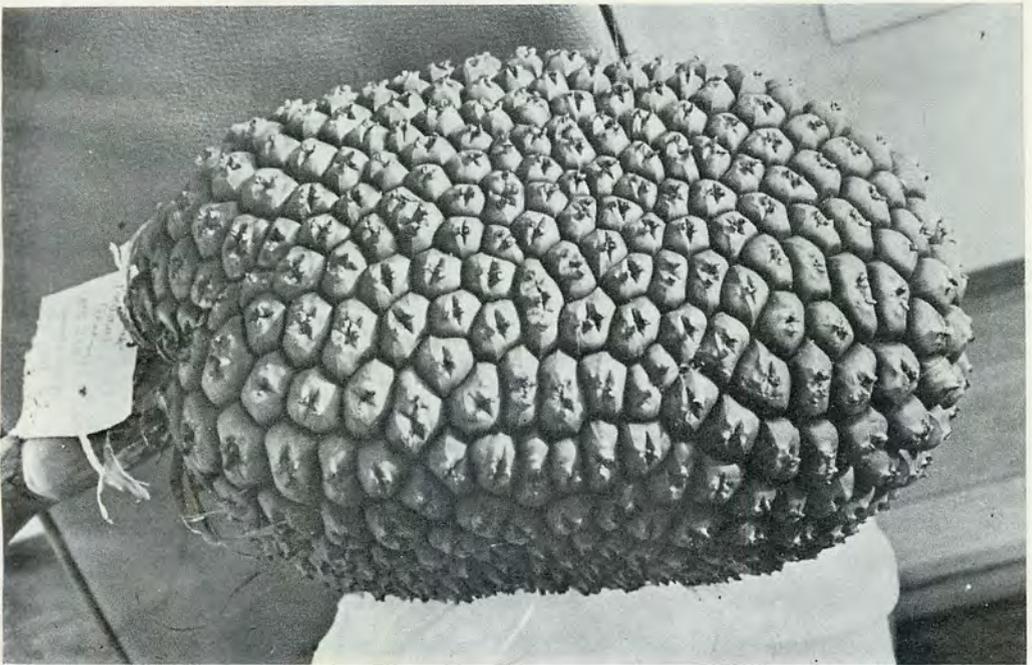
A common, distinct, though variable species, distributed from at least Bombay to Ceylon, around the Bay of Bengal along the shores of Burma, Thailand, Malaya, West Sumatra (at least), Cambodia, Vietnam, as far north as Hong Kong, Formosa, Ryukyu Islands, Philippines, and Borneo. In the literature commonly confused with *P. tectorius*. Martelli combined the two species and used first the name *tectorius*, later *odoratissimus*, for the concept. Lately numerous synonyms, allegedly "new species", have been proposed by St. John, none of which, however, have very good characters.



P. toei St. John (BCS. 9617).



(A) *P. odoratissimus* L.f.



(B) *P. kaida* Kurz (BCS. 9318)

THAILAND: Southeastern; Lem Dan Kao, Kaw Chang, seashore, 2-10-1924, *Kerr 9290* (BK!). Kaw Chang, 2-4-1959, *Smitinand 5463* (BKF!). — Rayong, Ban Phe, sealevel, 20-11-1963, *Smitinand 8422* (BKF!). — Peninsular; Narathiwat, Ban Thon, along coast, 7-5-1961, *B. Sangkhachand 128* (BKF!). — Khao Tanyong, 4-2-1961, *Smitinand 7110* (BKF!). — Trang Prov., Ko Muk Noi, 18-2-1966, *Sakol Sathisor 891* (BK!). — Kaw Tao, Surat, 12-4-1927, beach, *Kerr 12681* (BK!). — Bush in village, male flowers scented, *No. 531*, (BK!).

CAMBODIA: Prek Ampil, 16 km w. of Kampot, sandy beach, 19-5-1960, *St. John. 26345* (BKF!). (This specimen bears a manuscript unpublished name "kampotensis" but it is unquestionably *P. odoratissimus*).

Note: the specimen collected by Schmidt, and determined as *P. tectorious* var. *sinensis* Warb. by Ostenfeld, belongs here. The var. *sinensis* Warb. is in fact, the same as *P. odoratissimus*. It has also been named *P. remotus* St. John, another synonym.

(2) *Pandanus kaida* Kurz, *J. Asiat Soc. Bengal* 38 (2): 148. 1869. Stone, *Malayan Agriculturist* 9: 34. 1970. [Plate VI-B]

Old synonym: *P. siamensis* Williams, *Bull. Herb. Boiss.* 220. 1904.

As I have recently discussed this plant in considerable detail, adding data on my Cambodian and Malayan collections, I need not repeat these here. Collections are as follows.

THAILAND: Central; Bangkok, riverside, Jan. 1922, *Eryl Smith 241* (BK!); *A. Marcan 656* (BM!). Southeastern; Chanthaburi, Makham, paddy field, 20 m. alt., 9-3-1970, *Smitinand 10,788* (BKF!). Peninsular; Between Haadyai and Song Khla, in ricefield, 23-3-1960, *Smitinand 6592* (BKF!)—a large specimen, the fruit of 7 heads in 1 spike).

CAMBODIA: Near Skoun north of Phnom Penh, 28-2-1960, *Smitinand 6555* (BKF!). — Kbal Tuk, Khum de Ampil, 5 km w. of Kompong Cham, rice fields, 24-5-1960, *St. John 26,350* (BKF!). — Near Skoun, rice fields, March 1970, *Stone 9318*. (KLU!).

(3) **Pandanus tectorius** Warb., Pflanzenr. 3, IV. 9: 46, 1900.

Cultivars: *P. sanderi* Hort., *P. veitchii* Hort.,
P. baptistii Hort., *P. spurius* Miq.
 CV "pudak" St. John.
P. laevis Rumph. ex Kurz.

These rather variable cultivars, which probably are all mere forms of *P. tectorius*, have been noted in Bangkok.

IV. Sect. **RYKIA** (*De Vr.*) Kurz

As mentioned above, this section seems to contain the greatest number of problematical species in our region. The following species have been attributed to Thailand: *P. bifidus* St. John, *P. obconicus* St. John, *P. reticulosus* St. John, *P. acaulescens* St. John, *P. ligulatus* St. John, *P. penetrans*, St. John, and *P. unicornutus* St. John. Besides these seven species definitely known from Thailand, several others from adjacent areas, may turn out to occur as well; e.g. *P. furcatus* Roxb., of N. Bengal and Assam, (already noticed on herbarium labels in BKF), *P. unguifer* Hook. f., of N. Bengal, Sikkim, and *P. cupribasalis* St. John, which is from Cambodia. Some one or more of the Vietnamese species of this Section might also eventually be found in Thailand and/or Cambodia. At present, the taxonomy of this group is in confusion and the following records must be considered only fragmentary and provisional.

(1) **Pandanus unicornutus** St. John, Pacif. Sci. 17: 489. 1963. [Plate VII]

This is a large arboreous species with spicate heads of fruit, and comparatively large drupes many of which have simple styles, though some have forked styles. I have seen all the specimens cited by St. John (*Kerr 12,772*, the type; *Kerr 16,052*; both of these from Kaw Tao; *Kerr 10,432*, from Kanburi, 700 m. alt.; and *Kerr 11,601*, from Ta Ngaw, Chumpawn; all in BK). They are certainly conspecific. The species is however, quite similar in general to *P. penangensis* Ridl., which however has mainly forked styles. It is even more similar to *P. spinistigmaticus* Fagerlind, of Java. A rather similar specimen from Nepal has been seen

in the British Museum, identified as *P. furcatus*; but that species probably has solitary heads, to judge from Roxburgh's remarks, for he says in *Flora Indica* (p. 744, 1832) "Drupes of the oblong compound fruit cuneate, with an incurved, polished, sharp forked spine; nuts 1-celled." Roxburgh cites *Kaida Tsjerria*, Rheed. Hort. Malabar. ii, t. 8., as a synonym, but gives as localities also "native of Pegu, Chittagong, Malabar, etc." What is drastically needed is a good neotype collection of *P. furcatus*; only then can the other species be worked out. In the meantime *P. unicornutus* can be tentatively accepted. It is apparently rather easily distinguished from other Thai species of this section by its rather massive size (height 15m. with proproots; leaves to 385 cm long, 11 cm wide, with prickles to 7 mm long; cephalia 5 or 7 together in a spike, each 14-18 cm long, 11-12 cm thick, ovoid, 3-sided; drupes numerous, 35-43 mm long, 8-10 mm thick style simple, 6-8 mm long).

THAILAND: Peninsular; 9 kms. N. of Ranong, 50 m., *R.M. King 5580* (US!).

(2) *Pandanus penetrans* St. John, *Pacif. Sci.* 19: 534. 1965.

This species is described as a tree 9 m tall, with leaves to 300 cm long and 6.3 cm wide, having prickles to 4-5 mm long; the cephalium is solitary, on a long (65 cm) peduncle, 14 × 12 cm, broad ellipsoid, with nearly 600 drupes, these 33-35 mm long and 7-11 mm thick; the styles are 7-8 mm long, usually bifid, a few on the apex of the cephalium simple. It is based on a single collection from Doi Suthep, Chiang Mai, at 1200 m. alt. (*St John 26352* in BISH).

It should be closely compared with *P. ligulatus* and *P. cupribasalis*.

(3) *Pandanus ligulatus* St. John, *Pacif. Sci.* 19: 532. 1965.

Based on *Smitinand 4950* from Phu Krading, Loei, at 1300 m altitude. The plants are described as up to 3 m tall, with leaves to 400 cm long and 4 cm wide, bearing prickles to 4.5 mm long. The cephalium is solitary, 11 × 7.5 cm, borne on a peduncle 70 cm long. The drupes are 27-32 mm long, 5-8 mm thick with styles 6-7 mm long, usually bifid.

This seems suspiciously similar to *P. cupribasalis*, and also to *P. penetrans*; and possibly also to *P. bifidus*.

(4) *Pandanus bifidus* St. John, Pacif. Sci. 17: 475. 1963. [Plate VIII]

This is described from two specimens, the type from Pak Tong Chai, Nakhon Rachasima, at 200 m. alt. (*Kerr 8132*), and another from Kao Krading, Loei at 1200m. alt., *Kerr 20,084*. The leaves are up to 300 cm long and 5 cm wide, with widely spaced prickles; the cephalia solitary, 12×10 cm. Drupes numerous, 30-32 mm long, 8-11 mm wide, with styles 3.5-5 mm long, entire or bifid.

I have seen only one recently collected specimen which seems to accord with this species, but it differs in its much more globular cephalium and slightly shorter drupes. The leaves are slightly smaller but only bracteal leaves are present, so this is probably unimportant. It seems useful to give here a rather full description of this specimen.

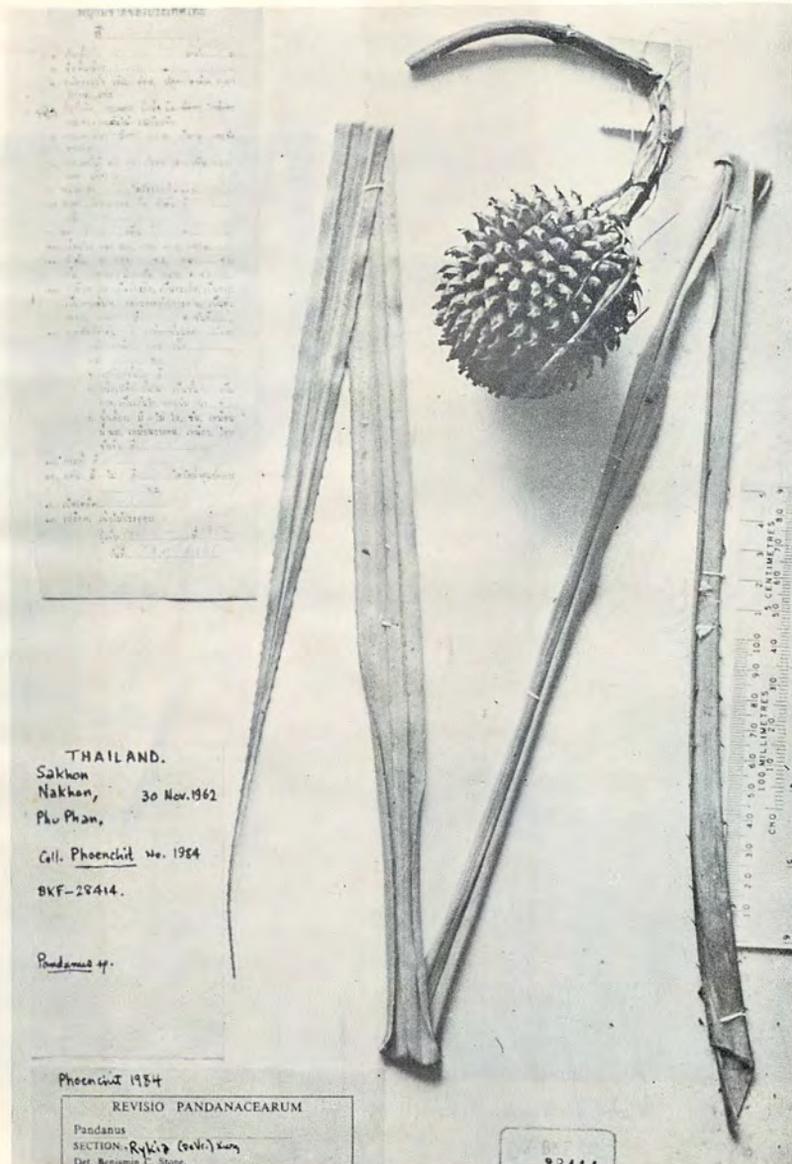
A shrub with leaves at least 120 cm long, 2.3 cm wide, linear-ensiform, gradually attenuate to the slender subflagellate apex; leafbase coriaceous, coppery-purplish. Midrib, near base, with reflexed slender rather dark somewhat distant prickles 2.5 mm long, 15-25 mm apart; near middle, virtually unarmed; near apex, with small teeth 0.5-1 mm long, 5-10 mm apart. Margins near base with antrorse prickles 2-2.5 mm long, 15-20 mm apart; near middle, teeth smaller and appressed; near apex, teeth 1 mm long or less, 3-5 mm apart, Reticulations of leaf middle and apex (dorsal side) not very obvious, small, long rectangular, to 1 mm long, longer than wide.

Fruit solitary, on a 15-17 cm long peduncle, 8-9 mm thick near apex, more slender below; ripe head subglobose 7×6.5 cm (less mature heads smaller, somewhat more ovoid); leaves to 350 cm long and 6.1 cm wide; somewhat narrowed (4 cm) at base; prickles to 3 mm long. Cephalium solitary 14.5×9.3 cm, on a long (56 cm) peduncle, ellipsoid, with almost 700 drupes, these 33 mm long, 7-10 mm thick, with styles 4-6 mm long and bifid, about 200-300 per head, all 1-celled.

Drupes $26 \times 9 \times 5-6$ mm, excluding the style, much compressed transversely, wider than thick; pileus 5-6 mm long. This and 1-2 mm more of the drupe apex free (in dry state). Pileus steeply pyramidal, hexagonal. Styles glossy brown, mostly 4 mm long, usually forked halfway into divergent fairly slender rather sharp lobes. Endocarp



P. unicornatus St. John (R.M. King 5580 Ranong.)



Pandanus bifidus St. John, forma. (Phloenchit 1984)

median, 12×4 mm, the wall $\frac{1}{2}$ mm thick. Apical mesocarp about 5 mm high, pithy medullose. Seed 9-10 mm long. Lower mesocarp fibrous.

THAILAND: Sakon Nakhon, Phu Phan, *Phloenchit 1984* (BKF!). (In Herb. and Coll. Carpol.).

In the small globose heads, with strongly compressed drupes having steeply pyramidal pilei and regularly forked styles, this seems to be quite a distinct species. Unfortunately only a small collection was obtained, but luckily several cephalia, in differing states of maturity, were collected, and one of these seems quite fully mature.

(5) *Pandanus cupribasalis* St. John, *Pacif. Sci.* 19: 101. 1965. [Plate IX]

A species known (supposedly) only from Mt. Kam Chay, Bokor, Cambodia. I have collected this species in the type locality, where it varies in stature according to whether it occurs in the stunted 'elfin forest' or in the moist tall forest at e.g. Poporkville, where it may reach 8 m or so in height. The fruits seem invariably to be solitary. I was fortunate to find a staminate specimen, although the flowers were rather withered. The staminal phalanges are typical of Sect. *Rykia*, the stamens clustered at the apex of the stemonophore.

CAMBODIA. Bokor; Chaîne de l'Éléphant, Mt. Kam Chay, March 1970, *Stone & Tixier 9268, 9269, 9287, 9316, 9317* (KLU!).

(6) *Pandanus obconicus* St. John, *Pacif. Sci.* 17: 481. 1963. [Plate X]

Known so far only from S.E. Thailand, Chanburi, Makham, at 100 m. alt., common along the edge of a savannah in scrub forest. The type is *Smitinand 4054* (BKF). This is described as an acaulescent plant, with leaves to 100 cm long and 3.6 cm wide, slightly narrowed toward the base; prickles to 5-6 mm long, those on the midrib rather widely spaced and recurved (nearer the base). The small solitary cephalium is 7.5×4.5 cm, ellipsoid, with drupes 16-19 mm long and 4-9 mm thick; the styles very short, 2-3, mm long, with divergent, short lobes.

This plant is very similar to *P. reticulosus*, and should also be compared closely with *P. unguifer* Hook. f. (*P. minor* Buch.—Ham.). It

seems to be in a group of "dwarf" species of *Rykia* which includes, among others, *P. crinifolius* Martelli (of Malaya), *P. bicornis* Ridl. (of Malaya), and a couple of undescribed species from Sumatra and Borneo.

(7) *Pandanus reticulosus* St. John, *Pacif. Sci.* 17: 484. 1963.

Known only from Phu Krading, Loei, Tham Saw, at 1300 m. alt.; the type is *Smitinand 406* (BKF). This is perhaps an acaulescent plant, with leaves to 200 cm long and 5 cm wide, but narrowed to 3.8 cm near the base. The prickles reach a length of 6 mm. The midrib spines are remote and near the leaf base are reflexed. The solitary cephalium is 7×5.5 cm, ellipsoid, with drupes 22-26 mm long and 9-14 mm wide; the styles are 2.5-5 mm long, shortly bifid.

This could well be a synonym of *P. obconicus*, although the leaves seem to be more evidently reticulated, and the drupes slightly longer. It seems likely that these two could be combined; at any rate this would have to be compared with the relatives, mentioned above under *P. obconicus*.

(8) *Pandanus acaulescens* St. John, *Pacif. Sci.* 19: 529-532. 1965.

Type: *Smitinand 6746*, from Tat Noi, Chieng Mai, in a dry waterway at 900 m. alt. Acaulescent, with leaves to 350 cm long and 6.1 cm wide; somewhat narrowed (4 cm) at bases; prickles to 3 mm long. Cephalium solitary 14.5×9.3 cm, on a long (56 cm) peduncle, ellipsoid, with almost 700 drupes, these 33 mm long, 7-10 mm thick, with styles 4-6 mm long and bifid.

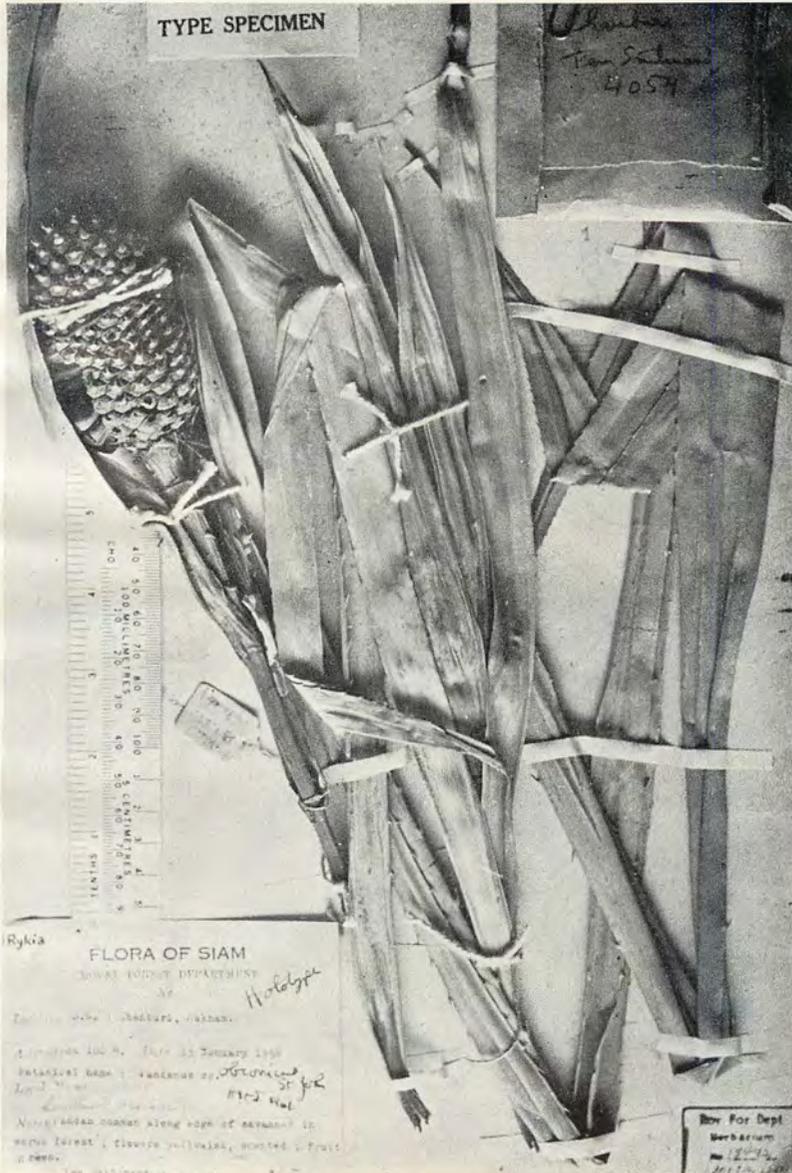
(9) *Pandanus* sp.? (*H.S.S. 11208*).

THAILAND: Northern; Khao Huey Khae, 800 m. alt., acaulescent plant, leaves purplish green, fruit globose dark bluish green, ripening yellowish pink, 21-2-1964, *B. Hansen, G. Seidenfaden & T. Smitinand 11,208* (BKF!).

This specimen bears a manuscript name indicating a new species, which it may be. The fruit was comparatively small. The leaves are very conspicuously reticulated, about 155 cm long and 6.6 cm wide, the apex acuminate, the base slightly narrowed (to 4 cm). This may be an undescribed species.



P. cupribasalis St. John. (BCS. 9317).



Pandanus obconicus St. John (Type).

(Note: *P. magnifibrosus* St. John, originally assigned to Sect. Rykia, belongs in Sect. Fusiforma, q.v.; *P. obovatus* St. John, originally assigned to Sect. Rykia, belongs to Sect. Hombronia, q.v.; *P. thailandicus* St. John, also originally assigned to Sect. Rykia, belongs to Sect. Solmsia, q.v.)

V. Sect. *SOLMSIA* Stone

This section, closely related to Sect. Rykia, was described recently (STONE 1967). Three species of this section are now reported from our area, all three from Thailand, and one from Cambodia. Two also occur in Vietnam.

Key to species

1. Cephalia (mature) under 10 cm long, subglobose to ellipsoid; drupes rather broadly obclavate. Leaves slender, with pale spines. Diminutive shrubs of forest streams. *P. fibrosus*
- 1 Cephalia (mature) commonly 15 cm long or a bit more; drupes slender, almost linear to slightly fusiform or very narrowly oblanceolate. Leaves slightly broader (to 3 cm), with dark spines. Small to medium shrubs up to 3-4 m tall, riversides or swamps in open country
 2. Cephalia oblong-ellipsoid. *P. militaris*
 - 2 Cephalia subglobose. *P. capusii*
- (1) **Pandanus fibrosus** Gagnep. [ex Martelli, 1937: 1066, fig. 100 (3-5), nom. et descr. franc.]; in Humbert, Notulae Syst. 6: 177, 1938. [Plate XI]

New synonyms: *P. thailandicus* St. John, Pacif. Sci. 17: 486, 1963.

P. gressittii B.C. Stone, J. Arn. Arb. 43: 348, 1962.

This species is very characteristic, and I have no hesitation in reducing to it the plant described by St. John from Thailand. The Hainan plants (which were mistakenly assigned at first to Sect. Acrostigma) also seem to be of the same species. The resulting distribution seems logical; the plants are found along streams and rivers in forested areas, in Northeastern Thailand and points east. Like all species of this section,

it is a rheophyte or subaquatic plant. Both the fruits and male flowers are well-described by St. John. The following additional specimens may be cited here:

THAILAND: N.E., Phetchabun, Nam Nao, 30-7-1964, common by stream in evergreen forest, *K. Bunchuai* 1964 ♂ (BKF!).—Nong Khai, Bueng Karn, Huay Poo, 100 m. alt., common by stream, 17-11-1966, *Smitinand* 10,088 ♀ (BKF!).—Sakol Nakhon, 30-11-1962, *Phloenchit* 1977 ♀ (BKF!).

(2) *Pandanus militaris* Warb., Pflanzenr. 3, IV. 9: 79, 1900. var. *militaris*.

[Plate XII]

THAILAND: Peninsular; Satul, Khuan Kalong Forest, 50 m. alt., common by streams, to 8 m tall, stem blackish, shining, with spines, proproots to 2 m., fruit oblong-ovoid, 12-2-1961, *Smitinand* 7148 ♀ (BKF!).

These specimens have the narrow leaves with attenuate apices characteristic of the typical variety, rather than the broader leaves and acuminate apices of var. *malayanus*; cf. STONE, in Malay. Nat. J. (1968).

First record of this species from Thailand.

(3) *Pandanus capusii* Martelli, Bull. Soc. Bot. Ital. (1903): 304. 1904.

[Plate XIII]

Syn. *P. pendens* St. John, Pacif. Sci. 19: 11, fig. 209. 1965.

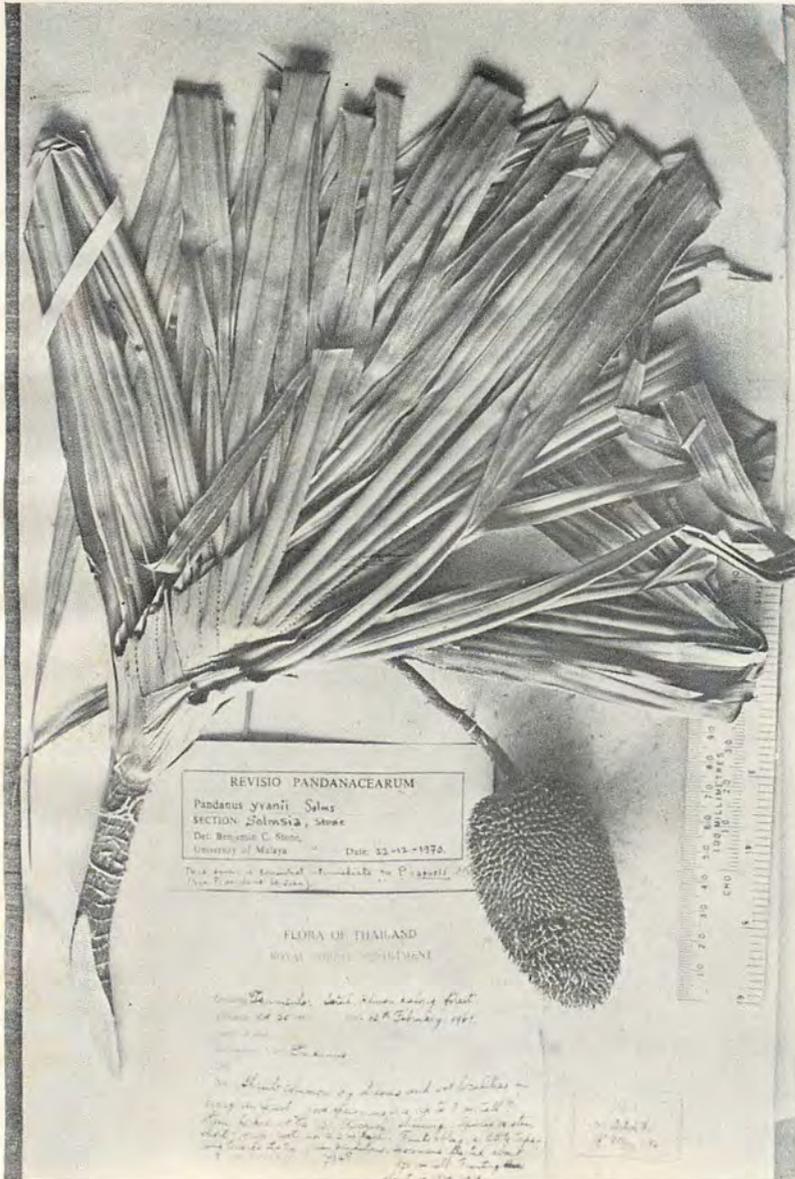
This species, described originally from Vietnam, can now be reported from Thailand. It is also to be found in Cambodia, as *P. pendens* is clearly the same species. This was originally (wrongly) assigned to Sect. *Acrostigma* but there is no doubt of its correct placement here.

THAILAND: N.E., Ubon Ratchathani, Nam Tok Sae, 21-2-1967, 3 m tall, by stream in forest, fruit brown, *Phusomsaeng* 8 ♀ (BKF!).

This locality, as well as some of the others, suggests that this species may be found here and there along the Mekong River and its tributaries. It is very similar to *P. militaris*, and scarcely differs from that species except in the very globose syncarp.



Pandanus fibrosus Gagnep. (Phloenchit 1977).



Pandanus militaris Warb. (Smitinand 7148).

The type of *P. pendens* was collected in Cambodia 1 km s. of Ph. Khdat, about $\frac{1}{2}$ km. inland, and 16 km. w. of Kampot, in a narrow wooded stream gulch some 10 m deep and at 15 m. alt., on 19 May 1960, by *St. John* (no. 26,344). The drupes were evidently loose from the fruit, so that their orientation could not be ascertained; this presumably explains why the species was incorrectly placed in Sect. *Acrostigma*. The slender drupes, caducous styles, and dark marginal teeth all point, however, to Sect. *Solmsia*.

VI. Sect. *HOMBRONIA* (*Gaudich.*) *Warb.*

(1) *Pandanus obovatus* *St. John*, *Pacif. Sci.* 17: 482, 1963. [Plate XIV]

THAILAND: Khao Luk Chang, Pak Chong, 4-7-1965, *Smitinand* 8860 ♀ (BKF!).

This, the second known collection of this remarkable species, is like the first also from a limestone hill. Clearly this will be one of the limestone endemics, a class of species belonging to various sections but usually very strictly confined to this rock type. The type collection, *Kerr* 7969 (BK!) was from Kaeng Khoi, a limestone hill quite close to Pak Chong.

St. John originally assigned this species to Sect. *Rykia* (quite reasonably), but I prefer to place it in Sect. *Hombronia*, a section which is however very closely related to Sect. *Rykia*. In doing this (and also placing here the following species, *P. calcis*), I rely on the characters of *P. dubius*, the type of the section. The large, plump, rather light, 1-3-celled drupes of *P. obovatus* are extremely similar to those of *P. dubius*, as are the large, not forked, stigmas. The orientation of the stigmas too, either facing each other, or all facing the apex of the cephalium, is just the same as in *P. dubius*. Finally the large copiously pithy-medullose apical mesocarp is similar, although the endocarp in *P. obovatus* is heavier and thicker.

P. calcis is clearly a close relative.

(2) *Pandanus calcis* *St. John*, *Pacif. Sci.* 17: 473. 1963.

This species, based on *Kerr* 11796 (BK!) and four other *Kerr* collections, all from limestone, is hereby placed in Sect. *Hombronia*. It

was originally assigned to Sect. *Microstigma*, but this is clearly a serious error, and it has nothing to do with that section. On the contrary, it is similar in most essential points to *P. obovatus*, although the drupes are much smaller.

A collection from Tham Klawng, 12 km n. of Chumphon, on a precipitous limestone knob at 75 m alt., 24-6-1960, by *St. John* (no. 26,364, BKF!) may belong here, but the drupes are old and eroded and neither pilei nor stigmas are present, so the determination cannot be quite certain. The drupes are also rather longer.

(3) *Pandanus dubius* Spr. Syst. Veg. 3: 897. 1826.

Syn. *P. pacificus* Hort. Veitch, ex Handlist Monocot., Kew Gard., 283. 1897. Nom. nud.

This species, the type of the section, has recently become popular in Bangkok as a potted plant (fide SMITINAND). I have seen one or two plants, usually very small, in cultivation. When planted out these may reach 10 m or more in due course. It is conceivable that the species may yet be found wild on one of the offshore islands; it occurs, for example, on Pulau Tenggol off Trengganu, but it is not known from the Malayan mainland.

Some remarks on the relationships of Sect. *Hombronia*

Section *Hombronia* was established in the first instance as the genus *Hombronia* Gaudich. (type sp., *H. edulis* Gaud.):— This species is the same as *Pandanus dubius* Sprengel. Warburg retained the taxon but ranked it as a section of *Pandanus*. He placed it adjacent to Sect. *Keura* (now called Sect. *Pandanus*), and included in it a few other species. Earlier, some species had been described by Brongniart from New Caledonia which were assigned to this section.

In *St. John's* survey of the sections of the genus (*Pacif. Sci.* 14: 224, 1960), 22 species were placed in Sect. *Hombronia*. It is not possible here to review all of these species, but some of them, at least, probably belong to other sections.

The traditional characterisation of Sect. *Hombronia* has been the structure of the drupes, especially the style and stigma:

Drupes one to several-celled; styles apical, erect or oblique; carpels (of 2-more-celled drupes) in transverse series; apical mesocarp very pithy; stigmas ventral, when 2 or more either facing each other or all facing the cephalium apex. Stamens racemosely clustered along the stemonophore. (Based on *P. dubius*). [The staminal characters of the Section given in St. John's key to sections are in fact those only of *Pandanus altissimus* of New Caledonia, which probably ought to be excluded from this section].

Besides the fruit characters, which have always played (and will always play) a major role in the classification of this genus, the anatomy of the leaves has recently been found to afford additional characters (see KAM and STONE 1970; KAM 1969, 1971). The foliar anatomy of Sect. Hombronia, based entirely on the type species, *P. dubius*, has been found to agree well with the comparable characters of Sect. Rykia. The stomata are all simple (Class I) and the epidermis is not zoned.

Now in fruit characters also, *P. dubius* accords very nicely with Sect. Rykia, differing as follows: drupes much larger usually and with copious pithy-medullose apical mesocarp; styles not forked; stigmas larger. *These characters also occur in Pandanus obovatus St. John and P. calcis St. John*, two endemic Thai species. Therefore I consider these two species as belonging to Sect. Hombronia although *P. calcis* was originally assigned to Sect. Microstigma, and *P. obovatus* to Sect. Rykia. Indeed, these species appear to show the near affinity of Sect. Rykia and Sect. Hombronia: *P. calcis* is virtually intermediate.

VII. Sect. ASTEROSTIGMA Martelli

Although no species of this section are known as yet from either Thailand or Cambodia, the section ought to be mentioned here because one species is found in Tenasserim, Burma, and thus may turn up in S.W. Thailand. It has only been collected twice, first by Helfer, and later, at Tavoy, by Russell. I have given an illustration and discussion of the species, *P. graminifolius* Kurz, in Fed. Mus. J. n.s. 12: 111-116, fig. 1. 1969.

It is a slender, erect shrub, found along streams. It ought to be easily recognized even if sterile, by the distant, slender and elongated spinular prickles of the dorsal midrib.

VIII. Section Unknown

(1) *Pandanus amaryllifolius* Roxb. Fl. Ind. 742. 1832.

This little cultivar, which has never been known to flower, has fragrant musky-scented leaves which are used in cooking certain dishes, particularly rice and agar jellies. I have verbal affirmations by Tem Smitinand and Dhane Phanichapol that this occurs in Thailand; but I have not seen specimens. In Malaya it is usually called 'pandan wangi' and is found in almost every kampong household.

(B) *FREYCINETIA* Gaudichaud

This genus of nearly 200 species consists entirely of woody climbers. On this basis it can nearly always be distinguished from *Pandanus*. In addition, the presence of membranous auricles (expansions of the basal leaf-sheaths) is characteristic of this genus and rather rare in *Pandanus*. Two species occur in Thailand, one in Cambodia.

Key to species

1. Leaves short, less than 35 cm long, narrowly elliptic to lanceolate, the auricles tapered or rounded and entire or minutely weakly denticulate; pedicels of fruits short and stocky, less than 2 cm long.
Fj. javanica
1. Leaves linear, to 100 cm long or more, gradually attenuate, the auricles elongated, often purplish, lobed at the apex and rather coarsely toothed; pedicels of fruits longer (2-4 cm). *F. sumatrana*

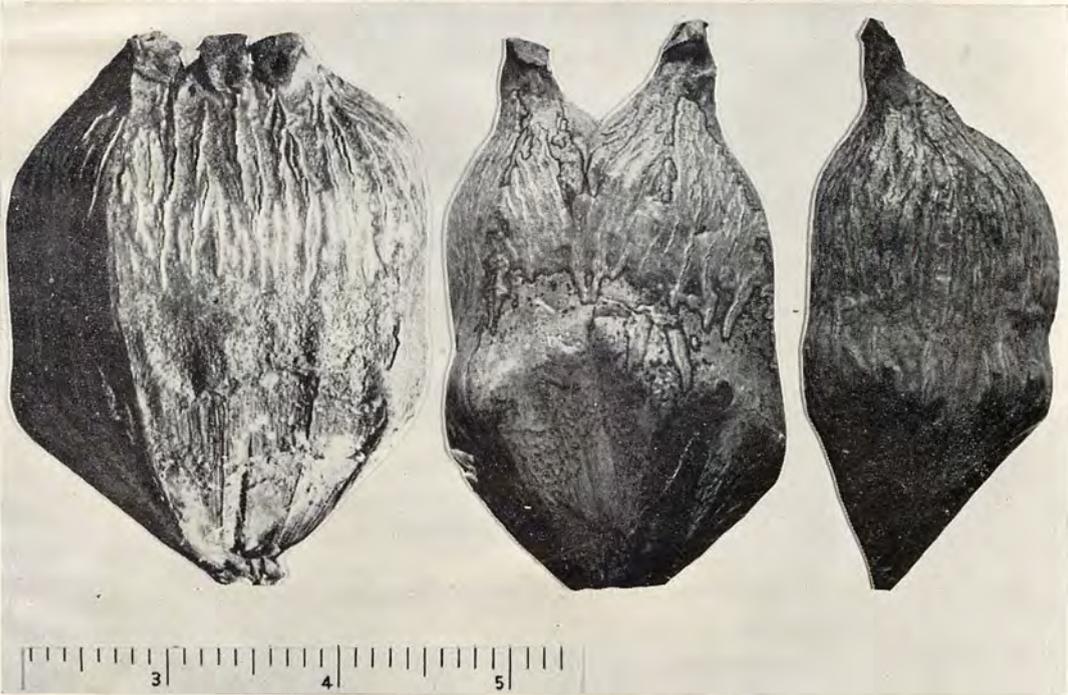
(1) *Freycinetia javanica* Blume, Rumphia 1: 156. 1835. Stone, 1970b: 195.

THAILAND: Peninsular; Nakhon Si Thammarat, Lan Saka, Chom Che Daeng, 440 m alt., 26-3-1955, *BKF* 12,888 (BKF!).— Khao Luang, Nakhon Si Thammarat, 30-4-1928, *Kerr* 15,488 (BK!).— Khao Kalakhiri, Pattani, 10-9-1923, *Kerr* 7781 (BK!).— no data, *Sanan Thuwon* 38 ♂ BKF!).

Note that the locality Khao Kalakhiri was wrongly spelled Khao Katakini in my original citation of this specimen.



Pandanus capusii Martelli. (Phusomsaeng 8).



Pandanus obovatus St. John. (Smitinand 8860).

- (2) *Freycinetia sumatrana* Hemsley, Kew Bull. 1896: 167;
Stone, 1970b: 199.

THAILAND: Trat; Kaw Chang, Khlong Nonsi, 20 m alt., 2-4-1959, *Smitinand 5664* (BKF!).— new record for the Flora of Koh Chang.— 100 m alt., 16-2-1955, *Smitinand 2167* (BKF!).— Khao Katha Khwam, 10-3-1930, *Kerr 18,510* (BK!).— Khao Kalakhiri, Pattani, 10-9-1923, *Kerr 7792* (BK!).

Also in Cambodia and Vietnam (cf. STONE and ST. JOHN, 1970).

III. NOTES FOR COLLECTORS

For collections of Pandanaceae in general to have maximum effectiveness, the following explanatory discussion and recommendations should be read and observed.

All members of this family are strictly dioecious, that is the plants are unisexual. The male plants flower presumably in certain seasons only, and the staminate inflorescences are very ephemeral, usually withering, decaying and disintegrating within two to four days. Therefore good staminate collections are lacking for many species. The female plants on the other hand, usually retain their inflorescences for long periods, perhaps up to a year or more, *even though pollination may not have occurred*. In other words the presence of a fruit on a plant, though it proves that the plant is female, does not necessarily mean that fertile seeds are present. Indeed even when germination occurs, one cannot assume that the progeny have been sexually produced, since good circumstantial evidence indicates that parthenogenesis (apomixis), as well as parthenocarpy, occurs in at least some species. The best known example is in *P. dubius* (KURZ, 1867) but the present writer has observed the same phenomenon in other cases (i.e., seedling production by isolated females in areas where no male trees of the same species are known to exist).

The occurrence of parthenocarpic and parthenogenetic phenomena almost certainly affect the characters—at least the dimensions—of the fruits. This can be seen readily on heads of fruit in which some, but not all, the ovules have been pollinated. In such cases (at least in species

with free drupes, not pbalanges), the drupes containing normal seeds are often very much plumper than the others. Of course, cutting open the endocarp will reveal the difference; the unpollinated carpels have empty endocarp chambers in which only a few longitudinal fibers, and the dried remnants of the ovule, occur.

Closely connected with this problem is that of gauging the relative maturity of the fruits. Half-developed fruit is certainly smaller than ripe fruit—but only a knowledge of completely ripe fruit will provide the necessary (maximum) dimensions. It is to be regretted that in most taxonomic descriptions of species of this family, no attention is paid to this. As a result, dependence on sheer dimensions—without knowledge of state of maturity—of the fruits, is naive, and usually very misleading. Unfortunately, great significance is often claimed for such measurements, and “new species” are often established on this kind of weak and essentially valueless information.

Another source of difficulty is the fact that pandans, in general, have comparatively large, bulky leaves. These are furthermore, usually well armed with sharp spines. The result is that most collectors, when they attempt to collect pandans at all, take a minimal and usually quite insufficient amount of material. For more “ordinary” plants, a good herbarium sheet will have several, perhaps dozens, of complete leaves, and some reasonable concept of variation in size, shape, etc., can be derived by a study of such a specimen. But with pandans, usually there are only a few, and very often only one leaf is present in the specimen, the others having been removed or cut away (all but the base). In fact there are some specimens with only a fragment of a single leaf, or even without leaves at all. Needless to say, such specimens make impossible any serious study of variation within a single individual, let alone within or between species. To add to the confusion, many specimens include only the leaves borne on the peduncle of the inflorescence; or only bracts; and a study of living plants quickly discloses how misleading such specimens can be. Only complete and fully adult leaves, from adult plants, will reveal the definitive foliar characters which may be of immense importance to the systematic botanist. Certainly the characteristic marginal and midrib spines, leaf-base texture and color, and anatomical

characters of value (such as stomatal elaboration) are found only on such adult leaves. Despite this, leaf descriptions in the original diagnosis of certain species may in fact be based on bracts or immature leaves—because these are often smaller, softer, and easier to collect.

Attention ought to be paid by collectors to habit. It is particularly important here to try to correlate observations of several individual plants which are clearly conspecific. For example, some species are acaulescent, i.e. the stem is extremely short or the above-ground portion virtually absent; species of Sect. *Fusiforma*, in fact, all have this character. This is a *genetic* character, not just an “adolescent” phase. In other species, however, although the adult plants may be trees, with a well-developed stem, the first or earlier *flowering events* may occur at a stage in growth before a well developed stem is present. Such plants are also “acaulescent”—*but will not remain so*, and the “acaulescent habit” cannot be used as a taxonomic character. Unfortunately such information is almost never available in published descriptions because it is usually not present in the collector’s notes.

In pandans, several phases of growth can be recognized (though perhaps rather artificially distinguished); seedling; young juvenile; older juvenile or “adolescent”; full adult; and senile adult. Besides this, one must remember that even adult plants when damaged or broken may produce “sucker shoots” which tend to have more “juvenile” characters. Taxonomic reliance on leaf characters—shape, dimensions, textures, etc.—has to be balanced by an understanding of these growth phases. Complicating this aspect is the phenomenon of *neoteny* (or paedomorphosis). For example fully *adult* leaves of *Pandanus crinifolius* may be almost indistinguishable from *juvenile* leaves of *Pandanus longicaudatus* (to use two Malayan species for discussion). Yet the former species remains a “dwarf”, in comparison with the latter. It would seem that here is an example of *genetical fixation* of the “juvenile phase” in the evolution of the species *P. crinifolius*. Therefore when *P. obconicus*, *P. reticulosus*, and *P. penetrans* are all described as “acaulescent”, we would wish to know whether it is a matter of “precocious flowering” or whether these species are genetically fixed as acaulescent.

The stunting effects of certain environments have to be considered as well. A good example is found in *P. cupribasalis*. On Mt. Kam Chay, in Cambodia, where this species is very abundant, the most numerous observations will be of those individuals occurring in the more open, stunted, "elfin forest" which is well-represented at 1000-1100 m. alt. But plants of the same species which grow on the lower slopes, or in the tall, moist forest at Poporkville Waterfall, may look very different, with much tatter trunks, up to 5-7 m, and longer, broader leaves. Here the effects of the environment are both obvious and very suggestive.

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