Survey of the genetic resources of *Piper methysticum* Forst. f. in Oceania

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Introduction

Kava, made from *Piper methysticum* Forst. f., is the traditional beverage of the Pacific Islands. *P. methysticum* is the only *Piper* species from which several flavones and chalcones have been identified (Sengupta and Ray, 1987). Experimental studies have shown that active principles of the plant, the kavalactones, have several physiological properties (Hänsel, 1968) which are presently used in the western pharmaceutical industry (Lebot and Cabalion, 1986). In order to study this underexploited crop with promising economic potential, it was decided to review the taxonomy, to conduct a survey covering its area of distribution and to collect, conserve and evaluate the germplasm. Specific objectives included an assessment of the relative contributions of genetic and environmental factors in the biosynthesis of kavalactones and an analysis of morphological and chemical variation in *P. methysticum* and related taxa.

Islands covered in this survey were: Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Wallis and Futuna, Western Samoa, American Samoa, Tonga, the Cook Islands, Tahiti, the Marquesas Islands, Hawaii and the Federated States of Micronesia (Fig. 1, Table 1).

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Methods

In 1986 and 1987, the major world herbaria were either visited (Paris Museum, Singapore, Lae, Bishop Museum) or invited to list their specimens of *P. methysticum* Forst. f. and *P. wichmannii* C. DC. (Kew Royal Botanical Gardens, British Museum, Rijksherbarium, University of Malaya, Bogor Botanical Garden, Queensland Herbarium, Royal Botanic Gardens in Sydney, Department of Scientific and Industrial Research in Christchurch, Missouri Botanical Garden and Arnold Arboretum). These specimens were compared with collections from Pacific herbaria located in the Solomons, Vanuatu, Fiji, New Caledonia, Tahiti and Guam.

P. methysticum is distributed from Irian Jaya to the Marquesas and has never been recorded in Indonesia, the Philippines, or South America, and *P. wichmannii* is found only in Melanesia. These two botanical species are the only ones in the genus *Piper* from which

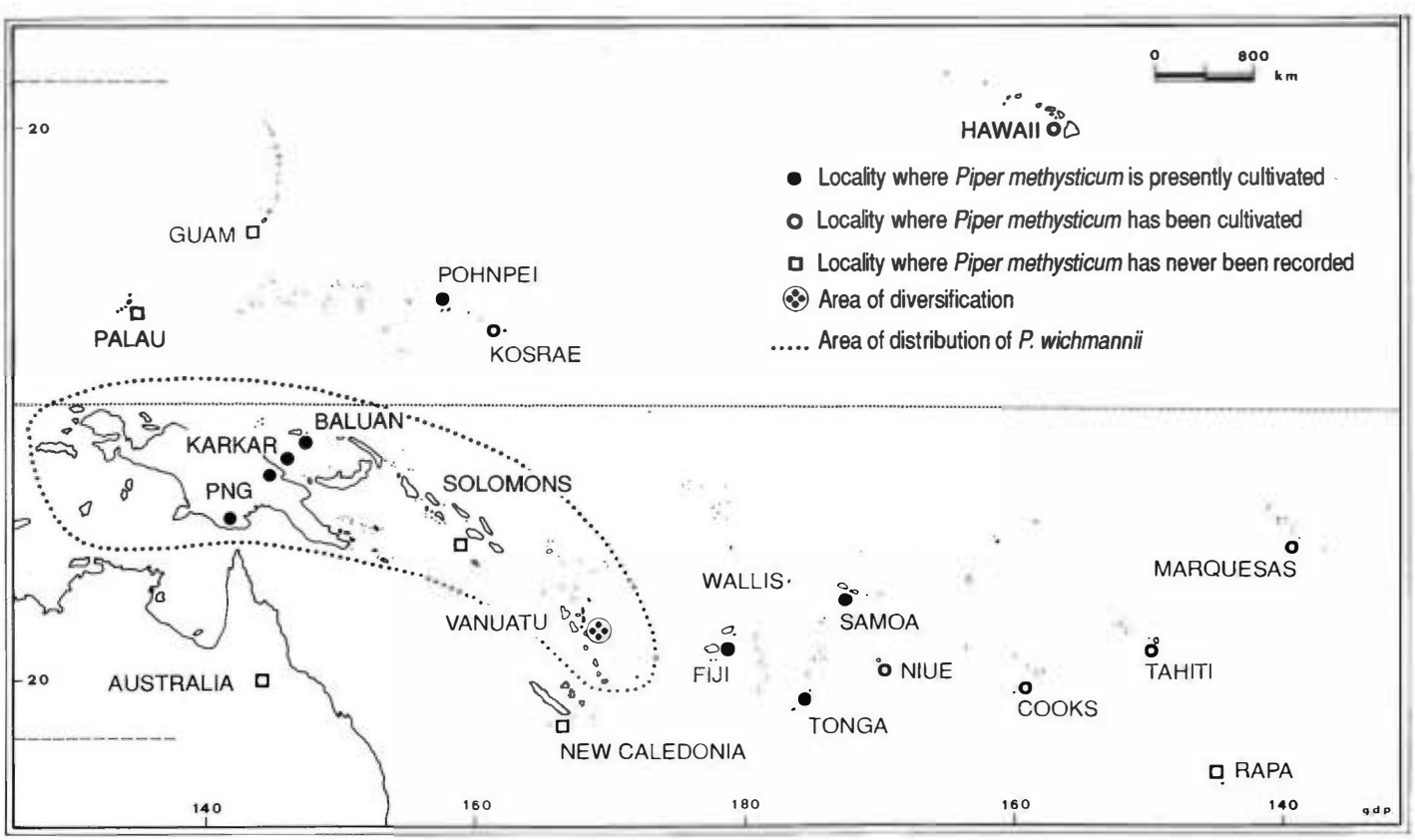

Fig. 1. Islands covered in the survey

Table 1. *P. wichmannii* and *P. methysticum* germplasm collected

Country/ island group	Islands surveyed	Accessions		Morpho-types
		Wild	Cultivated	
Vanuatu	23		247[1]	82
Fiji	3		16	12
Tonga	2		7	7
Western Samoa	2		6	6
American Samoa	1		5	5
Wallis and Futuna	2		6	3
Cook Islands	1		1	1
Tahiti	1		3	3
Marquesas Islands	5		1	1
Hawaii	2		11	11
Pohnpei	1		2	2
Papua New Guinea	5	2[1]	9	7
Solomon Islands	1	2[1]		1
TOTAL	49	4	314	118

[1] In Vanuatu, 6 accessions were cultivated forms of *P. wichmannii*, in Papua New Guinea and the Solomons, *P. wichmannii* grows wild.

kavalactones have been isolated (Lebot and Lévesque, 1989). None of the collections of *P. methysticum* was fertile, and female plants were uncommon. Local farmers confirm that *P. methysticum* is sterile. However, *P. methysticum* does flower; it is mostly dioecious but some monoeceous individuals were observed. Cytological studies have revealed that collections from Vanuatu, Fiji, Samoa and Hawaii, as well as a form of *P. wichmannii* from Vanuatu, possess a somatic chromosome number of 130 (Lebot, 1988). Since the basic chromosome number in the genus *Piper* is reported as x = 13 (Samuel, 1986), our studies indicate that *P. methysticum* is probably a decaploid. The high ploidy level may be at least partially responsible for the reproductive sterility observed in *P. methysticum*.

The plants were described during the second year of growth using a detailed list of descriptors developed for kava (Lebot and Cabalion, 1986). The chemical composition of each morphotype was analyzed. HPLC analysis of root samples showed that six major kavalactones represented 96% of the whole chloroform extract. Composition was coded in decreasing order of the proportion of each lactone present (codes were: 1 = demethoxyyangonin, 2 = dihydrokavain, 3 = yangonin, 4 = kavain, 5 = dihydromethysticin, and 6 = methysticin). The code differences allowed rapid recognition of the different chemotypes. Field experiments have shown that total kavalactone content and composition were independent of environmental conditions and age of the plant (Lebot and Lévesque, 1989).

Results

The collection exhibited large variation in kavalactone composition, which was used to characterize the germplasm.

Chemotypes A and B are exclusive to Melanesia and are found only in forms of *P. wichmannii*. However, forms originating from New Guinea and the Solomons (A) present different chemotypes than those from Vanuatu (B) (Fig. 2). Chemotype A has a very high proportion of demethoxyyangonin (25-35%) and a very low proportion of kavain (17-22%). Chemotype B is very rich in dihydromethysticin (38-58%) and dihydrokavain, these two kavalactones together accounting for 64-75% of the total, and the proportion of kavain was very low (<3%).

Chemotypes C, D, E, F and G all include morphotypes of *P. methysticum*. Chemotype C (254613)

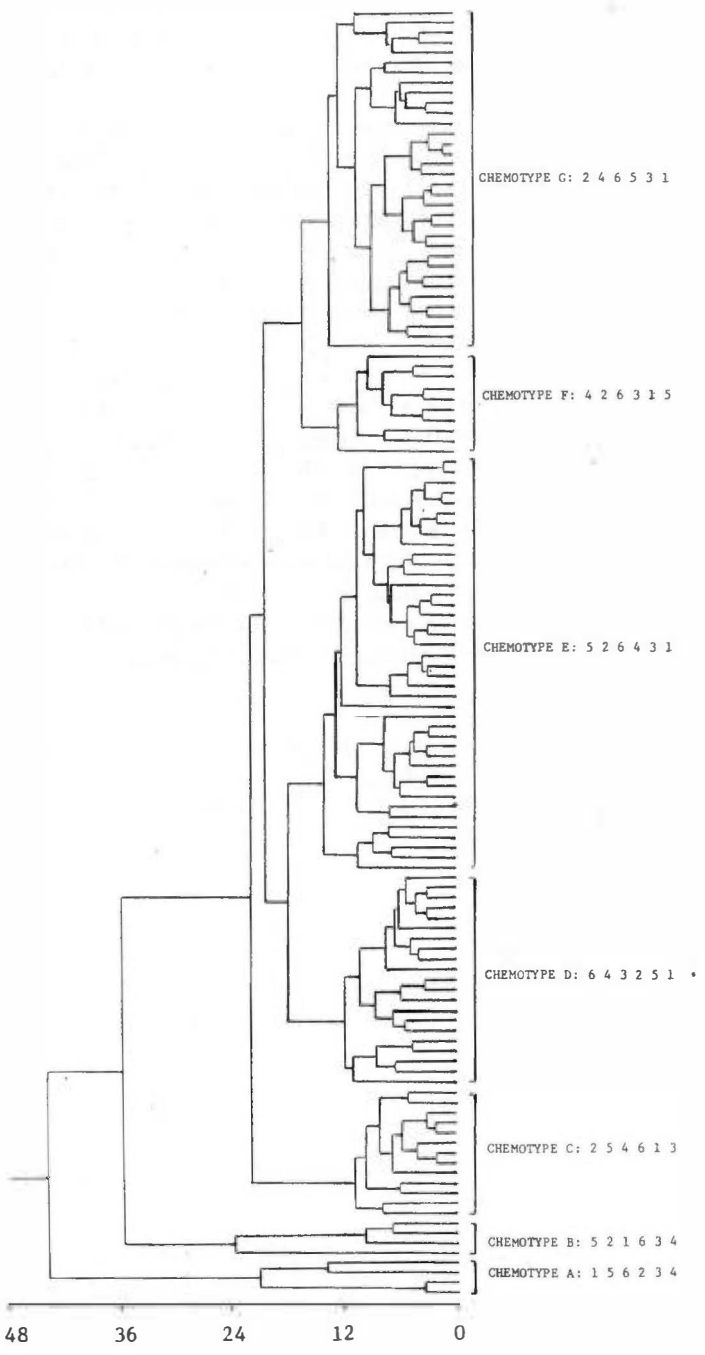

Fig. 2. Cluster analysis (UPGMA) using Euclidean distance of 127 root samples, of *P. methysticum* and *P. wichmannii*

has a very low level of yangonin and is represented only in Vanuatu and Papua New Guinea collections. Chemotype D (643251) appears to be endemic to Fiji, but is also present in Tonga, Samoa, the Cook Islands, Tahiti, Hawaii and Pohnpei. Surprisingly, this chemotype, which has a very high level of methysticin, is absent from Melanesia. Chemotype E (526431) produces a beverage with a very pronounced physiological effect, which is thought to be due to very high proportions of dihydrokavain and dihydromethysticin. This chemotype is present in Vanuatu, Tonga, Wallis, Fatu Hiva, Oahu and Pohnpei. Chemotype F (426315) is certainly the chemotype most appreciated by kava drinkers because of its high level of kavain. This chemotype is present only in Vanuatu and Western Samoa. Chemotype G (246531) is known to produce a beverage suitable for daily consumption, especially in the islands where the roots are consumed fresh (Vanuatu and Wallis).

Piper methysticum exists in only one morphotype in the northern part of New Guinea (Usino, Morobe, Madang and Karkar). The morphotype existing in the western province of Papua New Guinea (Fly River area) appears to be closely related to a morphotype originating from Vanuatu. The two morphotypes of *P. methysticum* grown in Baluan (Admiralty Islands) are also closely related to morphotypes originating from Vanuatu. Plants of *P. wichmannii* scattered among the Admiralty Islands, in Papua New Guinea and Vanuatu are quite similar morphologically but belong to different chemotypes. Collections from Baluan, Morobe and Guadalcanal are identical. A wild form originating from Karkar Island has a chemotype (215634) similar to the one in Vanuatu (521634). In Vanuatu, *P. wichmannii* has chemotypes similar to those of *P. methysticum* rather than to the wild forms of *P. wichmannii* occurring in other Melanesian islands (526431).

In Polynesia, it is easier to relate morphotypes of *P. methysticum* even if great distances separate them. It is obvious that an exchange of planting material has taken place between Fiji, Tonga, Samoa, Wallis and Futuna.

Conclusions

P. methysticum Forst. f. is a species whose area of distribution is restricted to the Pacific Islands; it is the only cultivated plant of such economic importance for which this can be said.

The name 'kava' includes two botanical species; *P. methysticum* is the botanical name used by botanists to identify sterile, cultivated kava, while *P. wichmannii* C.DC. is the name given to identify seeded, wild forms.

Pollination occurring in the wild between different plants of *P. wichmannii* is thought to produce very heterogenous progeny. Variability can be observed in both morphological and chemical characters. However, no correlations occur between morphotypes and chemotypes.

P. methysticum has reached its highest degree of diversity in Vanuatu. In this country, *P. wichmannii* is seedless and cultivated, although this species does produce seeds in Papua New Guinea and the Solomon Islands. The distribution of seeded forms is important in determining the centre of origin of this asexually propagated plant. Vanuatu is very probably an area of domestication of these wild forms.

Ongoing work is focused on the analysis of isozyme and cytological variations. It will soon be possible to correlate morphological, chemical and genetic variation for *P. methysticum* and *P. wichmannii*.

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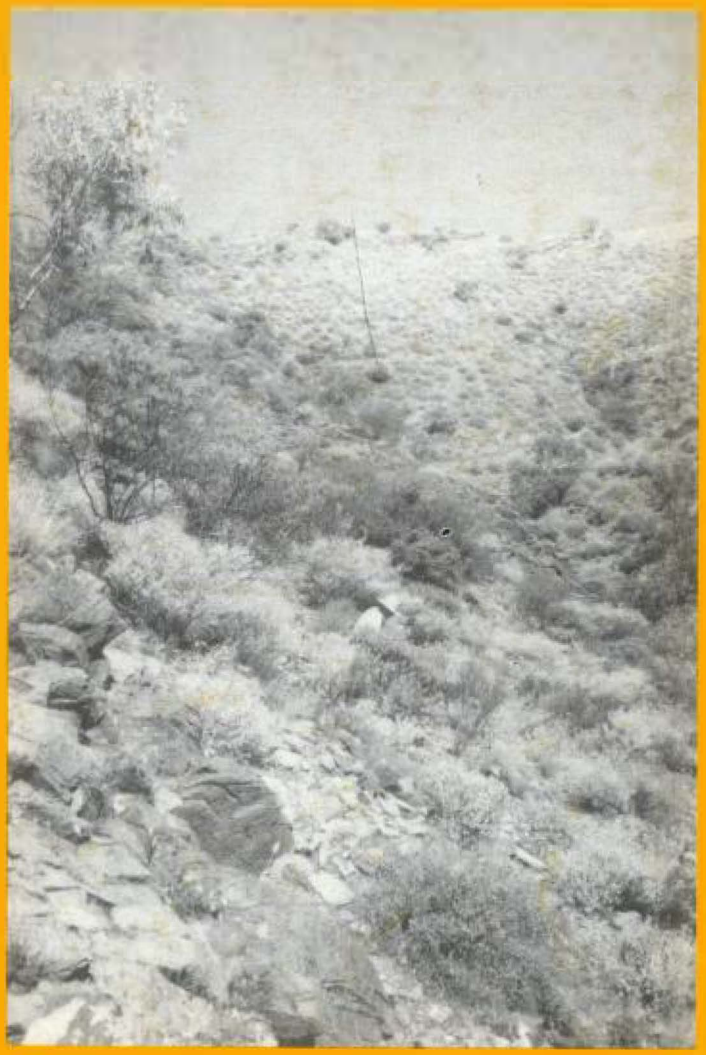

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