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## Ethnobotany and Ecology of Wild Taro (*Colocasia esculenta*) in the Philippines: Implications for Domestication and Dispersal

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In Southeast Asia and the western Pacific, the natural range of taro, *Colocasia esculenta* (L.) Schott, has been little studied and is poorly known. We have surveyed the distribution, ethnobotany, and ecology of wild taro in the Philippines, where previous authors assumed that wild taro is absent or derived from introduced cultivars. Wild taro is widespread, and may be naturally occurring in some areas. There is also widespread utilisation of wild taro as a leaf vegetable for food and fodder. Wild plants are managed as a shared, community food resource and are occasionally transplanted by people. In wet areas, the plants occupy a range of ruderal to apparently natural habitats. The leaves (blades and petioles) are widely used in popular forms of cooking in the Philippines. The stolons are also eaten, and less frequently the corms, and the entire leaves are also used as a fodder for pigs. The present variation, use and selection of wild taro may provide clues for understanding the domestication and dispersal of taro in the past. We also note the discovery of a little-utilised wild species of taro in northern Luzon, which is here identified as *Colocasia* sp. cf. *formosana*.

### 1. INTRODUCTION

Taro (*Colocasia esculenta* L. Schott) is best known as a tropical root crop with starchy corms, but is also widely cultivated in cool-temperate latitudes, in both hemispheres, and is used as a leaf vegetable in many countries. It is cultivated throughout the Philippine archipelago, but varies greatly in abundance—locally and regionally. In this paper we report the use of leaves and stolons from wild taro in the northern, central and southern Philippines. The corms are also used, but to a much lesser extent. We suggest that taro may be naturally distributed in the Philippines, as an indigenous wild species, and discuss the possible significance of wild taro use and management for primary or secondary domestication in the Philippines. We also note the discovery of another wild species of taro, *Colocasia* sp., which is here tentatively identified as *C. formosana* Hayata.

Taro leaves have two main parts, the petiole (i.e., leaf stem) and blade (large and heart-shaped). Mainly the petiole is used in Japan (Matthews 2004) and China (Jianchu *et al.* 2001,

Yongpin and Jianchu 2000). In the Eastern Mediterranean, use of the leaves has not been recorded (Matthews 2004, 2006). The petioles and blades are eaten in Nepal (Pandey *et al.* 2000), Vietnam (Nguyen 2000), and Myanmar (Matthews and Naing 2005). Taro leaves (*daun talas*) appear in many Indonesian recipes, but without the leaf parts identified (D.P. 1967). Throughout the Pacific islands, it appears that mainly the blade is used, together with coconut milk and other ingredients (Brennan 2000, and other recipe books). Thaman (1984) states that wild taro is often 'protected in streams or in the bush' in Fiji, and is an important green vegetable in villages throughout Fiji. Stolons and inflorescences can be obtained from wild or cultivated taros, and culinary uses have been reported in Myanmar and China. The use of wild taro as both food and fodder is widespread in Southeast and East Asia (Matthews *et al.* 1992; Matthews and Naing 2005; Jianchu *et al.* 2001).

The common name for taro in Tagalog and in the closely-related national language, Filipino, is *gabi*. This name is now recognised throughout the Philippines. Many other species-level names are used among the more than 100 languages spoken in this country (Madulid 2001), and a few examples are noted here. Wester (1924) listed ninety-five cultivar names, including near duplicates, and Papas (1986) listed a much smaller number of names for common or commercial taro cultivars.

### 1.1 History and Uses in the Philippines

In 1668, just over 340 years ago, the Jesuit priest I. F. Alcina wrote a detailed account of the use of aroids, yams, sweet potato and other root crops in the Visayas islands, central Philippines, and stated that (cultivated) taro, *gabi*, was considered the 'finest' of these crops. He also counted more than 78 names (i.e., cultivar names) for the plant and observed that the 'pulpy leaves' with their 'fleshy portion' (i.e., the petiole) were used for making 'stew' (Alcina 2002: 212–215). In the Philippines today, taro corms and leaves are commonly sold and eaten (*cf.* D.A.P. 1981) (Fig. 1). Within the period 1961 to 1985, estimates for commercial production of taro corms in the Philippines ranged from 86,000 and 155,00 tons, and taro ranked third in quantity of production, after cassava and sweet potato (both crops of South American origin) (Horton 1988). Wester (1924) ranked taro (*gabi*) as third in quantity of production after a sweet potato (*camote*) and yams (*ubi*, i.e., *Dioscorea* spp.), and reported that it is grown from sea level to at least 1000 m altitude, approximately, as an upland or aquatic crop. D.A.P. (1981) mentioned without citation a report on the revenue obtained from varieties of taro with edible leaves (i.e., blades) and petioles, and indicated that the leaves are of special importance as a vegetable delicacy in Bicol region of southeastern Luzon. Papas (1986) stated that some upland (cultivated) varieties are grown for their leaves (blades) and petioles, while the cooking expert Cordero-Fernando (1992: 181) commented that most *gabi* grow 'wild' in the Philippines, and suggested that obtaining leaves from wild plants explained (at least in part) the variability in itchiness (acridity) of the leaves used for cooking. Acridity in taro has been attributed to the presence of a specific enzyme (protease) that is bound to crystals of calcium oxalate, in the form of sharp, needle-like raphides (Bradbury and Nixon 1997).

### 1.2 Wild Populations and the Origin of Cultivated Taro in the Philippines

A schematic map presented by Matthews (2006) was the first attempt to compare the world



**Figure 1** Upper: fresh corms with leaves, from cultivation, Banaue town market, Ifugao. Lower: Dried entire leaves (blades and petioles) hanging upside down, in street market, Manila city (plant sources unknown). Note the presence of darker- (purple) and lighter-coloured (green) petioles (leaf stems); the greater number of green bundles may reflect a greater abundance and general preference for green forms of wild taro



distribution of cultivated taro and the likely natural range of wild taro. Botanical reports of wild taro in the Philippines were lacking, so the suggested natural range in Southeast Asia did not extend to the archipelago. All boundaries for the suggested natural range, in Southeast Asia and elsewhere, need revision based on field surveys aimed at locating natural wild populations. The survey reported here introduces the general appearance, ethnobotany and ecology of wild taro in the Philippines, and is a first step towards confirming the presence or absence of natural wild populations in this country.

Few authors have commented on the origins of taro in the Philippines, and those that

have all regard the plant as a cultigen introduced from somewhere else (see timeline below). The opinion of Merrill (1918), a leading botanical authority, appears to have been followed by later authors without question. Although Merrill described taro ambiguously as ‘at times ... at least subspontaneous’, he was certain that the plant was not native, and did not explain his opinion further:

‘The taro, widely known in the Philippines as *gabi*, is extensively cultivated, a number of forms or varieties being found in the Archipelago. It is at times at least subspontaneous, but is certainly not a native of the Philippines’ (Merrill 1918: 92).

In *Wild Food Plants of the Philippines*, Brown (1920) makes no mention of taro but other aroids are noted as wild food plants, so it is likely that the author did not regard taro as part of the wild flora. Brown is also cited by later authors (see below). Later authors also commented on the presumed introduction of taro as a crop:

‘Of the introduced and well-established species of tropical fruits [i.e., food crops] ... the most important [among the vegetables] are kamote [sweet potato], ubi [*Dioscorea* yams], gabi [taro] [and others]’ (Wester 1924: 11–12).

‘*Gabi* ... is a native of the Pacific islands’ (S.E.C. 1971).

‘This is one of the important food plants introduced into the Philippines during early prehistoric times’ (Pancho 1984).

‘Taro does not grow wild in this archipelago (Brown 1920). The limited isozyme variation observed among 146 cultivars indicates that *C. esculenta* is most likely an introduced crop’ (Lebot and Aradhya 1991).

‘The Austronesian model [of human movement] from Taiwan through the Philippines and thence eastward ... does not account for the introduction of plants such as taro into the Philippines’ (Peterson 2005).

Peterson (2005) cites the Kuk Valley in Papua New Guinea as the ‘earliest known origin’ for taro (with reference to archaeological reports by numerous authors), and suggests that taro was transported westward from New Guinea. Others have also proposed a westward movement into the Philippines. Lebot and Aradhya (1991) surveyed isozyme variation in 146 cultivars collected from throughout the archipelago and maintained by the Philippine Root Crop Research and Training Centre at Baybay, Leyte. The cultivars displayed remarkably little variation, and statistical analysis of the isozymes showed Philippine cultivars lying within an ‘Oceanian’ grouping of cultivars distributed from the Philippines to Micronesia, Papua New Guinea and Polynesia (ibid: Fig. 2, Table 2). DNA variation was subsequently analysed by Kreike *et al.* (2004) in a set of 255 taro accessions from across Southeast Asia and the Pacific. These authors proposed that Pacific taro cultivars were most likely domesticated in Papua New Guinea and the Solomon Islands, and were then carried westwards to the Philippines and



eastwards to Vanuatu. This proposal must be regarded as provisional, since few wild taro plants were analysed (none from the Philippines), and Philippine cultivars were not compared with cultivars in coastal China, the nearest possible source area in the Asian mainland.

### 1.3 Physical Environment and Climate

For surveys of agricultural crops and their wild relatives, the Philippine archipelago is a challenging region to work in. Large areas lack any road access, and the few roads present in mountainous regions are frequently damaged by landslides and flooding, especially during wet periods and the typhoon season. The archipelago has a complex geography, with numerous island groups and deeply dissected mountains. The mountains reach altitudes of almost 3,000 m in two of the main islands (Luzon and Mindanao), and the archipelago extends more than 1,200 km from tropical to subtropical latitudes (5°N to 21°N approximately). Despite the wide latitudinal range, the main climatic regimes are most strongly differentiated on a West to East axis because the archipelago is exposed to competing continental and oceanic weather systems. From the western continental side to the eastern oceanic side, four main climate types are recognised (PAGASA 2007). These are numbered in a sequence that follows seasonality, from strong (Type I) to weak (Type IV), but here we wish to emphasise the dry to wet geographical axis:

#### *Drier climates*

Type I: Two pronounced seasons, dry from November to April, and wet in other months (mainly along the Luzon Sea and Palawan Passage coasts)

Type III: Seasons not very pronounced, relatively dry from December to February or March to May, and wet in other months

#### *Wetter climates*

Type IV: Rainfall more-or-less evenly distributed throughout the year

Type II: No dry season but with a very heavy rainfall from December to February (mainly along the Pacific coast, where typhoons most commonly make landfall)

### 1.4 Habit, Growth, and Flowering of Taro

Taro is a soft, leafy herb with low tolerance for drought, and is unable to compete with woody vegetation. When soil and temperature conditions are good, and light is limited, the vertical leaf stems (petioles) can become greatly elongated (2 to 3 m). This allows the leaf blades to catch light. Plant height is thus much more variable than other morphological characters such as blade shape, or the shape and colour of corms (the underground storage organs), and side-corms. Stolons (elongated side-shoots from which new plants grow at nodes) are also highly variable in length, but the factors affecting their growth are not obvious, and have not been studied. The plant requires continuous water supply, but tolerates a wide range of light, nutrient, and temperature conditions. As an irrigated crop, taro can be grown in very low rainfall areas (Matthews 2006), and when planting stocks are protected during winter, some cultivars can be grown in very cool climates (Matthews 2002). In the Philippines, taro is best grown at altitudes from sea level to 1800 m, and (within these limits) can be grown at any time and

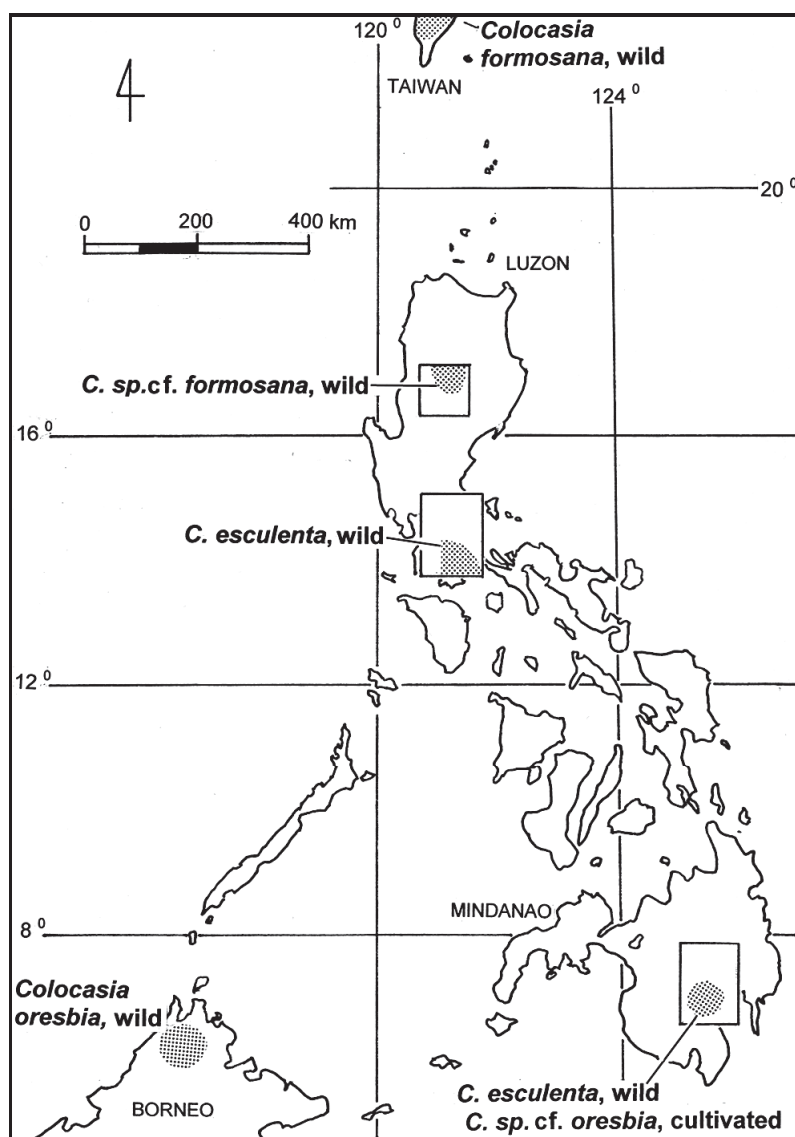
anywhere as an irrigated crop, and at any time as rainfed crop in areas without a strong dry season (D.A.P. 1981, Papas 1986). The leading taro-producing areas are generally wet to very wet, with Type IV or Type II climates (Camarines Sur, Samar, Leyte, Iloilo, Negros Oriental, and Cotabato Provinces), and the main growing season for taro is during the wettest months. Another important production area, Cavite Province (D.A.P. 1981), is close to the metropolis of Manila. This list of production areas is illustrative, not comprehensive. The provinces of Laguna and Quezon are also popularly known sources of taro (close to Manila), as are the large, supra-provincial regions of Bicol and Visayas.

In wild habitats—whether ruderal (obviously disturbed) or apparently natural (not obviously disturbed)—and in rainfed cultivations, the geographical distribution, growth rate, size, and flowering of taro plants are very closely linked to local climate and water supply, soil fertility, harvesting patterns, and vegetation cover. The full sequence of flowering, fruiting and seed production by wild or cultivated taros (*C. esculenta*) has only been reported in tropical to subtropical regions of Asia and the Pacific. Alcina (2002/1668) observed that cultivated *gabi* 'do not produce any fruit or even seed, but only a stalk when they are large'. His observation is likely to be from Leyte island, where he lived for many years. On the western coast of Leyte, Pardales (1981) surveyed 299 cultivars of taro at the Philippine Root Crop Research and Training Centre at Baybay, and reported large variation in flowering ability under 'natural' (i.e., outdoor) conditions in an experimental field. Among the 53–61% of cultivars that flowered, the flowering period began in May, reached a peak in July and August, then gradually declined and ceased in September (ibid 1981). In *A Flora of Manila*, Merrill (1912a) reported September to December as the flowering period for taro cultivated in low, wet areas. In different regions of the Philippines, it is likely that the flowering of taro follows different seasonal patterns.

## 2. METHODS AND TERMINOLOGY

To learn about wild taro in the Philippines, we examined herbarium specimens in the Philippine National Herbarium (PNH), and conducted field surveys in three areas (Fig. 2) on a north to south axis through the Philippine islands: (1) Northern Luzon—vicinity Banaue town, Ifugao Province (May 2008), (2) Central Luzon—vic. Mt Arayat, Pampanga Province (February 2009), vic. Manila City, Metro Manila (all visits, 2006–2009), and vic. Mt Banahaw, Laguna Province (March 2006, May 2008, February 2009), and (3) Mindanao island—vic. Davao City (Davao Del Sur Province and Davao Del Norte Province), and vic. Mt Apo, North Cotabato Province (March 2009).

Since taro is a distinctive and large herb, the fieldwork generally consisted of visual surveys from a vehicle with occasional halts to examine plants and interview local residents. In some locations, walking surveys were carried out on local foot-trails with the assistance of local guides. Where possible we also met with local town and city officials, and agricultural experts, to learn more about both wild and cultivated taros. Within each area, we looked for wild taro in a range of environments, following local environmental gradients from lower to higher altitudes, from lower to higher annual rainfall, and from urban to rural, agroforest, and from ruderal to apparently natural habitats (streams emerging from forest, and valleys ex-



**Figure 2** Survey areas in the Philippine archipelago (schematic boxes). From north to south, boxes represent the areas of Ifugao, Pampanga-Quezon, and Davao del Norte-North Cotabato. In each area, the shaded part indicates an approximate focus of distribution for the plant taxa indicated. Data for Taiwan and Borneo are from sources cited in the text

tending into forest). In the short time available, we were unable to explore remote locations with natural disturbance, where naturally distributed taro might be recognised most easily (stream banks, waterfalls, landslides and other gap habitats in forest, distant from roads and upstream from settled areas). Information about uses and cooking methods was gathered during interviews, and also by studying popular books on Philippine foods and cooking



methods. Such books are treated here as an additional source of field data.

For convenience, we use the phrase ‘wild taro’ to indicate self-propagating patches of taro on uncultivated ground in or alongside roads, trails, fields, ditches, canals, ponds, agroforest, flood channels, lakes, streams and waterfalls. These were mostly ruderal (disturbed) habitats, or were obviously modified by humans for purposes other than growing taro, but we also found wild taro growing at the edge of forest, or slightly within forest, where the habitats were natural, close to natural, or apparently natural.

Most of our travel was conducted during relatively dry weather. Wild taro was most easily found by looking for locations that are wet even during the dry season. During interviews, the main topics investigated were: (i) local names for wild and cultivated taro, (ii) the known history of local wild taro patches (planted or spontaneous?), and (iii) local uses of wild taro as food, fodder, or medicine. We also looked for insects that might be closely associated with taro, since these can provide clues regarding the indigenous status of the host plant.

Living plants of taro with edible leaves were collected from uncultivated, ruderal habitats in the vicinity of Mt Banahaw, Laguna Province. To prepare the plants for transport, we washed the roots to remove soil, wrapped the corms, stolons, and roots in damp newspaper, removed the largest outer leaves to reduce transpiration, attached a label directly to each plant, and placed each plant in an open or loosely-tied plastic bag. Bagging was needed to keep samples separate and to create a humid but well-aerated environment for the plant. The plants were donated to a living collection of taro maintained by Dr Teresita H. Borromeo and her colleagues at the College of Agriculture, University of the Philippines at Los Baños.

### 3. RESULTS

The results of our herbarium survey, and field survey from north to south (Fig. 2), are summarized below. For each field area, we comment on distribution, habitats, abundance, management, variation, naming, and uses. Initial observations of insects associated with taro are also noted in the final section.

#### 3.1 Philippine National Herbarium (PNH)

The herbarium was established in 1903, destroyed during World War II, and rebuilt in 1946. By 1990, it had 170,000 specimens, the largest collection in the Philippines (now housed at the National Museum in Manila), followed by the Los Baños (CAHUP) Herbarium with 60,000 specimens (Holmgren *et al.* 1990). One example of taro collected by R. B. Fox in the vicinity of Mt Pinatubo (25<sup>th</sup> May 1948, field no. 409, PNH 4595) was part of a collection of 500 plants, from diverse taxa, made in 1947–48 during a study of the ethnobotany of the Pinatubo Negritos (Fox 1952: 173). PNH 4595 substantiates the observation by Fox (1952) that those people were planting taro and letting it grow in various naturally wet locations in their landscape. Fox (*ibid*) also reported a Pinatubo word for ‘taro flower’ but said nothing further about the matter. Of particular interest is the collection of wild, flowering taro by D. R. Mendoza (10<sup>th</sup> June 1953, field no. 1338, PNH 18384) Mayon volcano, Albay Province, Luzon, at an altitude of 1000 m, in the bed of a creek in forest. The collector’s label reads:

‘wild gabi native in forest, never introduced in this place’. The two specimens noted above represent very different explanations for the presence of wild taro, but the contexts are not identical and the explanations are not mutually exclusive. Conklin and Buwaya (Banaue, 1962, PNH 78651) collected the vegetative parts of a cultivated variety (see below) that was said to have an edible inflorescence (*hungyaahuy maqan*). This may be the first report of the use of taro inflorescences in the Philippines.

Specimens with inflorescences have been collected over a wide range of dates, from a variety of locations:

- 10<sup>th</sup> June 1953 (wild, Mayon volcano, Luzon; coll. Mendoza, PNH 18334),
- 10<sup>th</sup> November 1953 (Mt Yagaw, Mindoro; coll. Conklin, PNH 19293 & 19300), and
- 10<sup>th</sup> December 1962 (PNH 78650—‘accidental’ in irrigation ditch; an old type (*mihday tuubuna*) with stolons; only the leaf is used, Banaue, Luzon; coll. Conklin and Buwaya; and PNH 78651—*laaqat qan banig*, Ifugao dialect name; in paddy; coll. Conklin and Buwaya).

### 3.2 Vic. Banaue Town, Luzon Island

Lat. 16°55'N, Long. 121°03'E, 1000–1500 m a.s.l., in Mountains near Mt Polis (2010 m), Ifugao Province; Type III Climate

At altitudes up to about 1000 m, taro was seen planted as a minor crop in terraced ponds alongside rice, on the bunds and banks between rice terraces, in ditches or channels running alongside or through the terraces, and in house gardens. It was also planted opportunistically, along with other vegetables, on road banks and on eroded dirt deposits lying on road edges. The morphology of taro growing in such locations varied. Some had a wildtype morphology with long stolons, but such plants might also be local cultivars, which include stolon-bearing forms. Roads here are cut deeply into steep hillsides, so there is frequent erosion of topsoil from slopes onto road surfaces. A mostly green and apparently wildtype form taro (*C. esculenta*, plants with white basal parts, relatively small corms, and long stolons — cf. Matthews 1997; Matthews and Naing 2005) was seen growing on a small waterfall above the road at about 1300 m in Pitwan village. The leaves of roadside taros, whether wild or cultivated, are generally regarded as edible, and can also be cooked for pigs. The leaves of wild *Schismatoglottis* sp. can also be fed to pigs, and are generally not favoured for human consumption. Another edible aroid, *Xanthosoma sagittifolium* was common in the vicinity of settlements, along roadsides, in house gardens, and in other open areas. It is planted as a source of corms for people, and of leaves for pigs, and in some locations has become naturalised (wild). Around Banaue, this South American species became common recently, within the living memory of local residents.

Roads in Banaue and nearby valleys follow contours between large areas of terracing, on the lower valley slopes, and secondary rainforest or agroforest on the upper slopes that rise steeply from around 1000 m. Where perennial streams or springs were located at the edge of forest, along roadsides, we found a morphologically distinct wild form or species of taro (*Colocasia* sp. cf. *formosana* Hayata) growing on stream banks, and among rocks next to small waterfalls, at five locations. At one location, an open and sunny stream bank, a large plant was found with immature inflorescences. Local inhabitants regard this wild form as

inedible, though it is known as an emergency food among men who travel in the forest. The initial discovery by D. A. Madulid, and subsequent studies of this wild form, will be reported in detail elsewhere.

Local names for aroids included the following: *C. esculenta* = *aba* (which also refers to the edible corm), *gabi*, *latud*, *pihing/pising* (Kalanguya dialect of Tinok, Benguet), *robingan* (Ayangann dialect); *C. sp. cf. formosana* = *aba-aba* (lit. 'like taro'); and apparently also *kep-kedung* (lit. 'white', in Kalanguya dialect of Tinok, Benguet); *Alocasia macrorrhizos* = *galian* or *vila*; *Schismatoglottis* sp. with edible petioles = *pi'o*, *pikok*; and *Xanthosoma sagittifolium* = *vila* or *San Fernando*.

No distinct name was found for apparently wildtype taro (*C. esculenta*), and few locations were found. A number of informants indicated that wild taro is more widely distributed in the survey area. We have not been able to survey less accessible locations to confirm this, and further road surveys in November 2011 did not provide any confirmation. Flowering of cultivated taro was reported by a few people, and specimens with inflorescences were previously collected at Banaue by H. C. Conklin (see above). In contrast, *C. sp. cf. formosana* was common, appeared to be naturally distributed above the main agricultural zone, had a distinct local name, *aba-aba*, and was recognized by local inhabitants as a wild plant associated with forest streams. At one location (a stream emerging from forest), we found a large plant with immature inflorescences, and an informant from the Tinok area (near Banaue) also reported having seen this wild form flowering.

### 3.3 Vic. Mt Arayat, Luzon Island

*Mt Arayat (15°09'N, 120°46'E, 1026 m), Pampanga Province; Type I Climate*

This mountain is an isolated volcano rising abruptly from a low surrounding plain. The seasonally heavy rainfall sustains a number of permanent springs that supply villages and rice fields at the base of the mountain and in the surrounding plain. The mountain is not high enough to attract clouds and rain during the dry season, and supports a relatively open woodland forest. A few patches of apparently wildtype taro were seen in wet ditches in Arayat village, and more were said to grow around the rice fields. These patches are used as sources of leaves for eating. During the dry season, the village and fields are supplied with water from a single large natural spring at the foot of the mountain. The close association of taro with irrigated areas, in and near the village, suggests that the plant was transplanted here from elsewhere. Land clearing and drainage of former swamps near the base of the mountain could have led to a loss of natural habitats for wild taro in the area, but from our observations, we cannot recognise the presence of a wild or natural source population.

### 3.4 Vic. Manila City, Luzon Island

*Manila City (14°36'N, 120°59'E, on Coast), Metro Manila; Type I Climate*

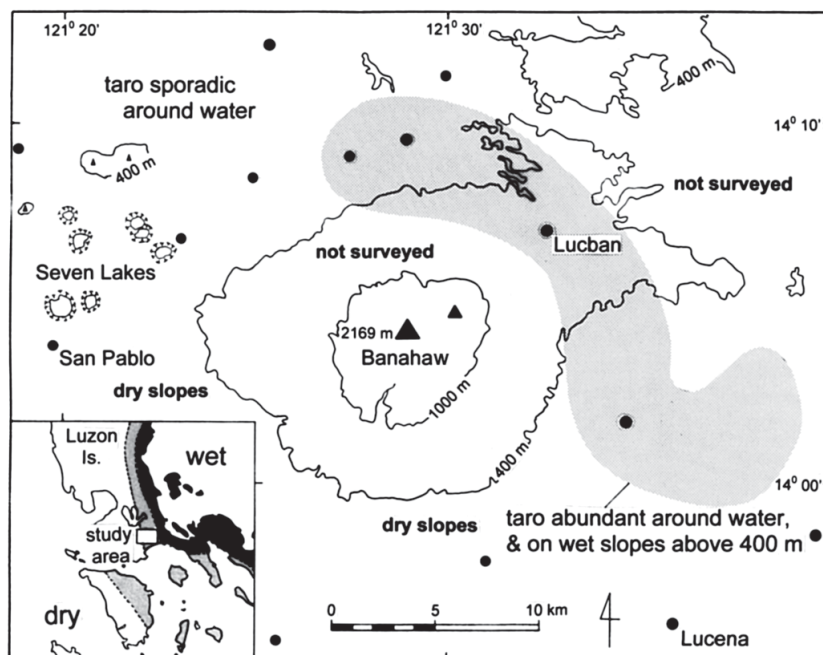
The metropolis of Manila is located just above sea level on a low-lying isthmus between a large freshwater lake (Laguna de Bay) and the sea (Manila Bay), is subject to frequent flooding during the wet season, but experiences a long dry season. Wildtype taro was not seen in city parks, vacant lots, waste places, or ditches. In *A Flora of Manila*, Merrill (1912a) recorded the distribution of other taxa in such habitats, but not taro.

### 3.5 Vic. Mt Banahaw, Luzon Island

*Mt Banahaw (14°08'N, 121°28'E, 2169 m), Laguna and Quezon Provinces; Climate Type III on Western Side to Type IV on Eastern Side*

In 2006, an initial exploration was made by Matthews around permanent springs and streams at the edge of forest in Hidden Valley, Laguna, in a volcanic region approximately 80 kilometers south of central Manila. A mainly green and apparently wildtype taro (*C. esculenta*, cf. Matthews 1997; Matthews and Naing 2005) was found. The same form was also seen in 2008 at the edge of forest in the nearby foothills of Mt Makiling National Park, to the west, and around the edge of Lake Sampaloc to the east. From 13<sup>th</sup> to 16<sup>th</sup> February, 2009, we visited Lake Sampaloc and the adjacent Lake Bunot, then followed a circular route around Mt Banahaw, a high volcano located near the wet eastern side of Luzon (Fig. 3).

The community around Sampaloc has a long history, extending back centuries to before the filling of a maar crater with water, after an eruption dated by local legend to about 500–700 years ago. The present lake edge is almost entirely settled, with huts and houses located on one or both sides of a road that circles the lake. A ruderal flora occupied roadside banks and ditches, and wild taro was abundant in many wet places along the roadside. We found three distinct forms growing alongside each other. One form was entirely green with stolons (possibly the same form identified as *gabi laing* at Lake Bunot, nearby), another was similar



**Figure 3** Area surveyed in the vicinity of Mt Banahaw, in Luzon. Wild taro was most abundant on the wet mid-altitude slopes, near the town of Lucban. Inset shows position of the mountain in a boundary region between the wet and dry zones of Luzon. Black circles mark small towns, which in turn mark the main areas of agricultural activity

in leaf colour, but the corm skin was slightly pink (*gabi bako*), and a third had a dark purple colour on the petioles and stolons (*gabi ligaw*). All were said to have edible leaves, but our informants generally preferred the leaves with green petioles. We saw cut petioles on many living plants. This showed that leaves were harvested without disturbing the corm. One woman mentioned replanting shoots after taking leaves, and occasional eating of the corm of a variety with green leaves. The frequency of deliberate planting or replanting could not be assessed during our rapid survey, but the different wild forms were all obviously self-propagating, with spreading stolons. The public road and roadside together form a very favourable environment for the spread of wild taros used as a communal food source, since they provide open many banks and ditches suitable for self-propagation and growth, a route for easy dispersal by people, and a route for easy access for harvesting.

Inside the nearby lake basin of Lake Bunot, there is no road. Instead, a narrow communal foot-trail passes through settlements on the lake shore. We found taro growing in small patches, without obvious cultivation. These are used as sources of corms and leaves. The morphological variation was similar to that seen around Lake Sampaloc, but the patches were located on private land, which extends down to the water's edge, and the plants were considered private property. One patch that was originally planted had an apparently wildtype green form with stolons, was identified as *taro laing*, and was said to be 'well used' for cooking.

In wetter locations close to Mt Banahaw, self-propagating and occasionally planted forms of wild taro were abundant in wet, ruderal habitats over a large region (Fig. 3). The people we met in this area generally did not recall patches being established by planting. One villager told us that some wild taro is planted, while some comes up by itself. A family in Barangay Lawigue (B. = village) reported that they had previously planted taro with edible leaves in the ditch outside their house, along the public roadside. This apparently wild-type form was well-established and self-propagating with stolons. The family explained that other people can take leaves from the plants, but the family would expect to be asked for permission. At B. Maloa, cultivated taro was growing on a steep roadside bank above a ditch with running water. In the grassy border between ditch and road, an apparently wild-type taro was spreading by stolons, without cultivation. The owners of the garden called the plants between ditch and road *lain*, explained that it was not planted, and that they only eat the blade. A different form planted and cultivated by them is called *inaw*, and all parts (blade, petiole, and corm) are used (Fig. 4). Wild taro growing under trees in an agroforestry zone, above Lucban town, at the highest point in our survey (604 m) were self-propagating with stolons, and were said to 'come up by themselves'. One speaker explained that 'people from the lowland' come to collect taro leaves in this area; although it is private land, the farm owners do not mind if people collect the wild taro. *X. sagittifolium* was also wild and abundant along the roadside in the area. People collect the corms for sale, and the blades and petioles are collected as fodder for pigs.

Near Mt Banahaw, a mostly green and apparently wildtype form of taro was most common, but other forms had pink or red-skinned corms and roots, and lighter or darker purple petioles. For example, a purple wild form known as *gobat na laing*, was said to be 'itchy' (acrid) and 'not planted', at B. Bigo. These forms were similar to those seen around Lake Sampaloc. The related names *lain* and *laing* (leaf) may be used generally for any form,





**Figure 4** Wild taro growing alongside a wet ditch, at left, between the road and a field with taro. The wild and cultivated forms are morphologically distinct, and are managed differently. The wild form is a source of leaves for eating, and was not planted, according to the farmer using the field. The cultivated form on bank at right is a source of corms. Vic. Mt Banahaw, Luzon.

wild or cultivated, that is used as a source of leaves for cooking, while the name *gabi puti* or just *puti* (white) may be common for the green form that is pale or white near the base of the petiole. The name *gabi puli* was also mentioned in relation to wild taro in the vicinity of Lucban, and *gabi bako* was described there as a cultivated form grown for its corms. This suggests that the ‘*gabi bako*’ growing wild around Lake Sampoloc, and used occasionally for





**Figure 5** Wild taro (at upper right) alongside one of the Taytay Falls, Mt Banahaw. Earlier photos of the same waterfall show that the taro has colonised the edge of a small slip face, along with other wild herbs. (Photo Oct. 2008, courtesy D. Mateo)

corms, might have been transferred from gardens. People questioned near Mt Banahaw generally preferred the leaves of wild forms that lack purple petioles, as in the vicinity of Lake Sampoloc. One speaker also preferred using *X. sagittifolium* with a green rather than purple petiole, despite the fact that the petiole of this aroid is not eaten (the corms are commonly eaten). At B. Maloa, the name *inaw* was recorded as a local vernacular name for gabi in general.

We found taro flowering at Lake Sampaloc in May 2008 (a wild plant), and again in a village near the foothills of Mt Banahaw, in July 2009 (a cultivated plant). When asked, most people in the region told us that they had not noticed or seen taro flowering, but men working in the agroforestry area above Lucban recognised a sketch of the taro inflorescence, and so did an older farmer (with large taro garden) near Taytay Falls. Wild taro was abundant along roadsides leading up to Taytay Falls, above Majayjay (Fig. 3) at the edge of the Mt Banahaw San Cristobal National Park, and was photographed in 2008 on a recently exposed slip face at the edge of one of the waterfalls (Fig. 5, D. Mateo pers. comm. 2009). In summary, wild and apparently wildtype taro is abundant on very wet mid-altitude slopes of Mt Banahaw, at the edge of mainly natural forest and in settled areas, on the northeastern flank, but we cannot say if a breeding population is present or not, as we have not visited this area during the wet season, when flowering and fruiting is more likely. One of us (Tandang) revisited Mt Banahaw in 2010, and ascended to the upper slopes, above Lucban, but did not see further wild taro. Although the plants are mainly self-propagating, and grow without cultivation, some transplantation of wild taro was reported in the Mt Banahaw area (Table 1), so the plants in some locations can be regarded as 'semi-wild'.

**Table 1** Wild and semi-wild (planted without cultivation) taro with edible leaves, collected in vicinity of Mt Banahaw, Luzon Island, Philippines. Abbreviations: GPS 140441.5 E, 1212007.9 N = Global Positioning System, base map WP84, 14 deg. 04 min. 41.5 sec. East, 121 deg. 20 min. 07.9 sec. N; m = metres a.s.l., gr. = green, pu. = purple; wh. = white; see Matthews (1997) for explanation of terms.

No.	Date & site no.	Location	Description	Name; comments; notebook ref.
1	14/2/09-1	L. Sampaloc, B. Concepcion, roadside ditch; GPS 140441.5 E, 1212007.9 N, 114 m	gr. blade and gr. petiole graded to white, pk. basal ring, pk. roots, pk. skin, wh. cortex, wh. core, gr./wh. stolon w. gr./wh. bract,	(?); leaf (no inf. about stolon); PJM 1.23-24
2	14/2/09-2	spring at L. Sampaloc; B. Concepcion; GPS 140452.0 E 1212004.0 N, 114 m, roadside ditch and around pool at spring source	gr. blade with pu. margin and entirely pu. petiole, wh. basal ring, wh. roots, wh. skin, wh. cortex, wh. core, pu. stolon with pu. bract	<i>gabi</i> ; leaf, though more itchy than preferred type w. gr. petiole; no inf. about stolon; PJM 1.25
3	14/2/09-6	L. Bunot, B. Concepcion; GPS 140446.6 E 1212046.8 N, 123 m; on open grassy slope above foot trail	gr. blade, gr. petiole, wh. basal ring, wh. roots, wh. skin, brown stolon w. brown bract, young blades eaten (indictaed by cut petioles),	<i>gabi laing</i> ; corm not used, stolon not used; planted w/o cultivation, PJM 1.37
4	15/2/09-1	B. Bigo; GPS 135948.2 E 1213844.7 N, 111 m; planted at edge of road outside front yard of house	gr. blade, gr. petiole, wh. basal ring, wh. roots, wh. skin, wh. cortex, wh. core, wh. stolon w. brown bract	<i>laing</i> ; no inf. on about stolon; blade and petiole eaten; corm not eaten; planted w/o cultivation, PJM 1.48-49, 74
5	15/2/09-2	B. Mate; GPS 140001.4 E 1213822.7 N, 120 m; along roadside and edge of overgrown field	gr. blade, pu. petiole, wh. basal ring, wh. roots, brown stolon with purplish brown bract	<i>lain</i> ; only blade is eaten; petiole, corm, & stolon not eaten; <i>lain w. pu.</i> petiole more itchy than <i>lain</i> with gr. Petiole; PJM 1.49-51, 74
6	15/2/09-7a	Kaluran Palale; GPS 140235.2 E 1213949.2 N, 219 m; along roadside ditch in settlement	gr. blade, pu. petiole, wh. basal ring, red roots, wh. skin, wh. cortex, wh. core, brown stolon w. purplish brown bract	<i>lain</i> ; no inf. about stolon, leaf more itchy & less popular than no. 7 (next); PJM 1.57
7	15/2/09-7b	Kaluran Palale; GPS 140235.2 E 1213949.2 N, 219 m	gr. blade, gr. petiole, pk. basal ring, pk. roots, red skin, wh. cortex, wh. core; stolons present but not collected	<i>puti</i> ; corm, petiole & blade edible; no inf. on edibility of stolon; corm v. starchy though small; poss. same plant as cv <i>gabi inaw</i> at B. Maloa (ref. PJM 1.69-70) ; leaf less itchy & more popular than no. 6; elsewhere cultivated for the corms; PJM 1.57, 75
8	15/2/09-8a	Silangan Palale; alongside wall at edge of field inside spa area; GPS 140347.8 E 1214038.6 N, 85 m	gr. blade with pu. piko, petiole purplish or gr. at top grading into gr. and wh. below; wh. basal ring, pk. roots, wh. skin, wh. cortex, wh. core, wh. stolon with pk. bract	<i>puti</i> ; blade and petiole edible; no.inf. about stolon; PJM 1.59, 74
9	15/2/09-8b	Silangan Palale; alongside wall at edge of field inside spa area; GPS 140347.88 E 1214038.6 N, 85 m	gr. blade with pu. margin and pu. piko, main veins partly u. on underside of blade, petiole strong pu. at top grading into gr. and wh. below, wh. basal ring, wh. roots, wh. skin, wh. cortex, wh. core, wh. stolon with wh. bract	<i>pula</i> ; stolon not eaten, blade edible; petiole edible or not acc. to diff. speakers; PJM 1.59, 73
10	16/2/09-2.1	B. Paola, Lucban; in damp gully in coconut plantation above road; GPS 140529.5 E 1213220.7 N, 604 m	gr. blade, pu. petiole, pk. basal ring	<i>pula</i> ; mainly the blade is eaten; stolon eaten in a dish called <i>paksiw</i> ; spontaneous, not planted; PJM 2.4-10
11	16/2/09-2.2	B. Paola, Lucban; in damp gully in coconut plantation, above road; GPS 140529.5 E 1213220.7 N; 604 m	gr. blade, gr. petiole, wh. basal ring, red roots,	<i>puti</i> ; no inf. about stolon; mainly the blade is eaten; spontaneous, not planted; PJM 2.4-10



**Figure 6** Wild taro on stream bank at edge of a coconut plantation, near Kidapawan, Mt Apo, Mindanao. The larger leaves in upper area of the taro patch belong to *Xanthosoma sagittifolium*, a South American root crop that is now naturalised (wild) in many locations in the Philippines

### 3.6 Vic. Mt Apo and Davao City, Mindanao Island

*Mt Apo (07°00'N, 125°05'E, 2954 m), North Cotabato Province; and Davao City (07°05'N, 125°30'E, on Coast), Davao del Norte—Davao del Sur Provinces; Type IV Climate*

Wild taro was not obvious along the coastal road from Davao southwards towards Mt Apo, but became abundant on the lower, open slopes (often with grazed grassland) leading inland towards Mt Apo from the coast. In the vicinity of Bansalan, at approx. 180 m, large patches of wildtype taro were seen growing in the boggy hollow of what appeared to be a wet-season flood channel. As we ascended towards Kidapawan town, wild taro became more common, not just in wet ditches but also on open roadside banks, in grass fields, on stream banks (Fig. 6), and on grassy stream flats. At approximately 574 m, alongside the road on a broad ridge above Kidapawan, we observed a large area of wildtype taro growing in an open boggy field grazed by goats and carabao (water buffalo). Cultivated taro and *X. sagittifolium* were common in house gardens around Kidapawan, and the latter appeared to be spontaneous in patches near Kidapawan.

At around 800 m, slopes became much steeper, on deeply dissected hills, and the edge of largely natural forest and the approximate upper boundary of agroforest was reached. Abundant *X. sagittifolium* and two forms of taro were found growing alongside the road in an area with gardens. One form, with a larger corm, was identified by a passing farmer as a probable garden escape (shortly before B. Mamangan). The other had pink-coloured lower parts, and was distinct from the apparent wildtype seen at lower altitudes. The farmer however





**Figure 7** Wild taro growing in mud next to a seepage spring, above the Malbour River, Mt Apo, Mindanao

explained that she had seen wild taro on rivers in the mountains, and that these vary in their appearance. We continued further uphill to a hot spring and lake (L. Agko) at approx. 1,280 m. A small patch of wild taro (apparently wildtype) grew in a stream below the lake, next to an area with public pools and some gardening activity. In a nearby valley, at a similar altitude, we followed a foot trail along the Upper Malbor river, accompanied by a farmer who was tending a distant garden located on a large talus slope above the river. Further patches of wild and apparently wildtype taro (entirely green, with stolons) were found growing in seepage springs between the hillside and river bank (Fig. 7). The farmer explained that wild taro also

appears spontaneously on landslides above the river, and that landslide surfaces are favoured for gardening. He took us to the foot of a very large landslide, composed of mud and large boulders, and showed us a wild taro with long stolons and purple petiole, distinct from the more common, green wild form seen in the vicinity.

In summary, apparently wildtype taro (with mostly green leaves, white lower parts, and long stolons) was most abundant in the wet and humid lower flanks of Mt Apo, between 400 and 600 m approximately, with a more dispersed distribution in the lowlands at around 200 m and in the dissected mountain valleys above 800 m. The overall distribution was similar to that observed on Mt Banahaw, but the scope of our survey was more limited on Mt Apo, which could not be circumnavigated by road. The management of patches near settlements around Mt Apo follows the same pattern as at Mt Banahaw: plants growing on public land or along roads or trails can be harvested by anyone, and wild plants growing on private land can also be freely harvested, with permission from the landowner. Although the wild taro patches seen by us were said to be not planted, we were also told of people coming from the lowlands to obtain planting materials from wild patches along the Malbour river, on Mt Apo.

Various names were recorded for taro and other aroids near Mt Apo. Some instances are noted here: *Colocasia esculenta*: *gabi* (wildtype, not planted; blade, petiole, corm and stolons are all eaten; vic. Bansalan); *gabi-putih* (wildtype, 'white', not planted, young leaves, and stolons, are eaten; mature leaves are cooked for pigs; vic. Saguin); *suli* (a local Mindanao name, wildtype; corms and stolons are eaten, not the mature blades or stems; vic. Kidapawan); *ungkog* (cultivated in house garden, large plants with shiny, non-waxy (glabrous), blade; corms eaten or sold; vegetative traits similar to those of *C. oresbia* Hay, a wild species in Borneo; vic. Saguin); *angkog* (name for taro generally, Manobo language, vic. B. Mamangan; and Visaya language, vic. B. Ginatilan); *angkog na putih* (a wild taro, with green leaf colouring; maloto = purple; vic. Malbour river); *angkog na maloto* (a wild taro, with purple leaf colouring; vic. Malbour river) *gabi puti*, *gabi pula* (different names for wild taro with different colours, 'white' and purple, vic. B. Mamangan; the 'white' may refer to the basal white colouring on the petioles of otherwise green leaves, or to the generally pale colour of green plants in contrast to purple plants). *Alocasia macrorrhizos*: *badjang* (wild, Kidapawan; acrid stem is eaten after special preparation, vic. Saguin); *Xanthosoma sagittifolium*: *kan-lang* (only the corm is eaten, vic. Bansalan), *otia* (Manobo language; planted; corms eaten, leaves fed to pigs, Malbour river; cultivated in house garden, B. Ginatilan). *Schismatoglottis* sp.: *paksin* (wild aroid with edible spadix; the name might apply to a dish made from the plant part, not the plant; vic. Malbour river)

Although we were unable to see any taro flowering, we did meet a local farmer and hunter, near Kidapawan, who indicated (when questioned) that wild taros (*C. esculenta*) in the area do flower and that fruit inside the fruiting head are eaten by a common local bird, *limucon*. He was familiar with the bird, and aroid inflorescences, because he uses the red fruit of *A. macrorrhizos* (*badjang*) as a bait in spring-noose snares (*lit-ag* in Visayas, *siol* or *bitag* in Tagalog), to catch the bird. This information was confirmed in part by a visit to his home, where caged birds (*limucon*) and germinating seeds of *A. macrorrhizos* were seen. Seeds were scattered on the ground around the cage because the fruit was also used to feed the birds after capture. From this single interview, we cannot be certain that wild taro flowers and fruits

in the area, but it seems very likely, given the favourable environment and general abundance of wild taro in the area.

Our survey in Mindanao concluded with an excursion northwest from Davao City, through coastal lowlands into a drier, hilly, and largely deforested region in the vicinity of B. Marilog, below Mt Bato. Wild and apparently wildtype taro (the common green form with white basal parts, and long stolons) was only seen in the lowland area near Davao, in ditches and stream banks, and in what appeared to a natural wet-season flood channel on the west side of Mintal. This lowland area lies within the watershed of the northern Apo mountain range, which receives rainfall throughout the year.

### 3.7 Cooking Methods and Acridity

In city vegetable markets and supermarkets, taro leaves (blades and petioles) are mainly sold in a dried form, and are either whole or shredded. Dried leaves are sold in bunches (Fig. 1), but the shredded form is more durable and compact, and is more easily stored and distributed. We have not investigated the sources of taro leaves sold in the cities, but they may come from wild and cultivated sources. The petioles and blades of young leaves are commonly used to prepare *laing*, *pinangat*, and other dishes (Cordero-Fernando 1992) (Fig. 8). For *sinangang* (a soup) and *laing* (a sauce), the blade is cut or the petioles are peeled and cut. Dried leaves absorb flavours from other ingredients more readily than fresh leaves. For *pinangnat* (a leaf packet), fresh young blades are wrapped and tied around fish or shrimp paste, and then cooked in coconut milk. *Ginataan* is a common dessert using coconut sauce, sugar, and one or more of many possible starch sources, including taro corms. These dishes are all described, with variations, in cooking books published in the Philippines. The use of stolons is not described in any of the cooking books surveyed for this paper. Here we paraphrase instructions for using stolons provided by various people. The first example is from a village man in the vicinity of Bansalan, Mindanao.

“The stolon of wild *gabi* can be eaten with coconut; the young stolons don’t need to be scraped, older stolons can be peeled by finger. The thick stolons are best; short or long ones can be used. The stolons can be harvested in any month. Leaves and stolons are not mixed when cooking, though the method for cooking the stolon is the same as for leaves [i.e., for *laing*]: cook with a little water in a pan; the water is not discarded; cover the pan, don’t stir, then add coconut milk later. No oil is used. Aji [monosodium glutamate], salt, chili, onion, and garlic are added for flavour”.

Near Lucban, Mt Banahaw, we were told that young stolons can be cooked with fish and vinegar to make a dish called *paksiw*. In Ifugao Province, stolons are harvested from wild and cultivated forms of taro, and stolons from local taro cultivars are sold in bundles in Banaue town market. At Malbour river, Mt Apo, we were told that wild taro is used as a source of planting materials, in order to produce stolons for sale. Near Kidapawan, on Mt Apo, the following instructions were said to apply equally to leaves and stolons:

“The young leaf (or stolon) is used for a dish called *law-oy* [Visaya language]. To make this,



leaves are cooked with water, vinegar and salt, and then flavoured with onion, garlic, and no coconut milk. The vinegar is added at start, and the leaves are cooked until soft. They can also be cooked with soy sauce. Stolons are cooked separately, but in the same way as the leaf, and the dish has the same name. The wild taro is used. If the cook does not know how to cook it, the dish will be itchy. The itchiness can be cured by eating sugar.”

People in the vicinity of Mt Apo eat the younger leaves of wild taro, and use the older leaves as fodder for pigs. The use of leaves did not seem to be so important as at Mt Banahaw, eating the stolons of wild taro was mentioned more frequently, and the corms were described favourably as food. The use of leaves may be less frequent because of greater acidity, lower population density, the lack of large markets nearby, or a combination of these reasons. At Mt Apo, we were told that to eat the itchy corm, it should be peeled, chopped, and boiled, or boiled hard, until it is soft. This is essentially the same method for cooking the corm of a cultivated taro, but the latter was said to be easier to cook, because it takes less time and becomes softer. The corm of wild taro was said, in one interview, to be better and more sticky than the corm of ‘San Fernando’ (*X. sagittifolium*).

The most remarkable observation regarding the use of taro leaves, from wild or cultivated plants, is that the acidity (‘itchiness’) is a very general cause of uncertainty or concern. The removal of acidity by cooking does not appear completely predictable. During our interviews, from north to south, a great variety of explanations were given in response to questions about acidity and recipes for cooking taro leaves. Near Banaue, Ifugao, a village head reported that:

“The itchiness [when the *gabi* leaf is eaten] depends on the skill of the person cooking it; the cook can be anyone, male, female, young, old; my own wife does it well, but if I try to cook the same kind with the same technique, it becomes itchy. It is like rice wine; sometimes it is comes out bad, sometimes good. Some *gabi* is not itchy even if it is half-cooked, while other kinds can be cooked for a long time and still not be good. Some varieties are not itchy for the hands, and are only itchy for the mouth, depending on how they are cooked”.

Around B. Piit, close to Taytay Falls on Mt Banahaw, wild taro is abundant. In this village, a male elder stated:

“... when animals such as pig or horses or other domestic animals, scavenge around the wild taro, it [the leaf] tends to be itchy; the disturbance is like scratching, so that makes it itchy”

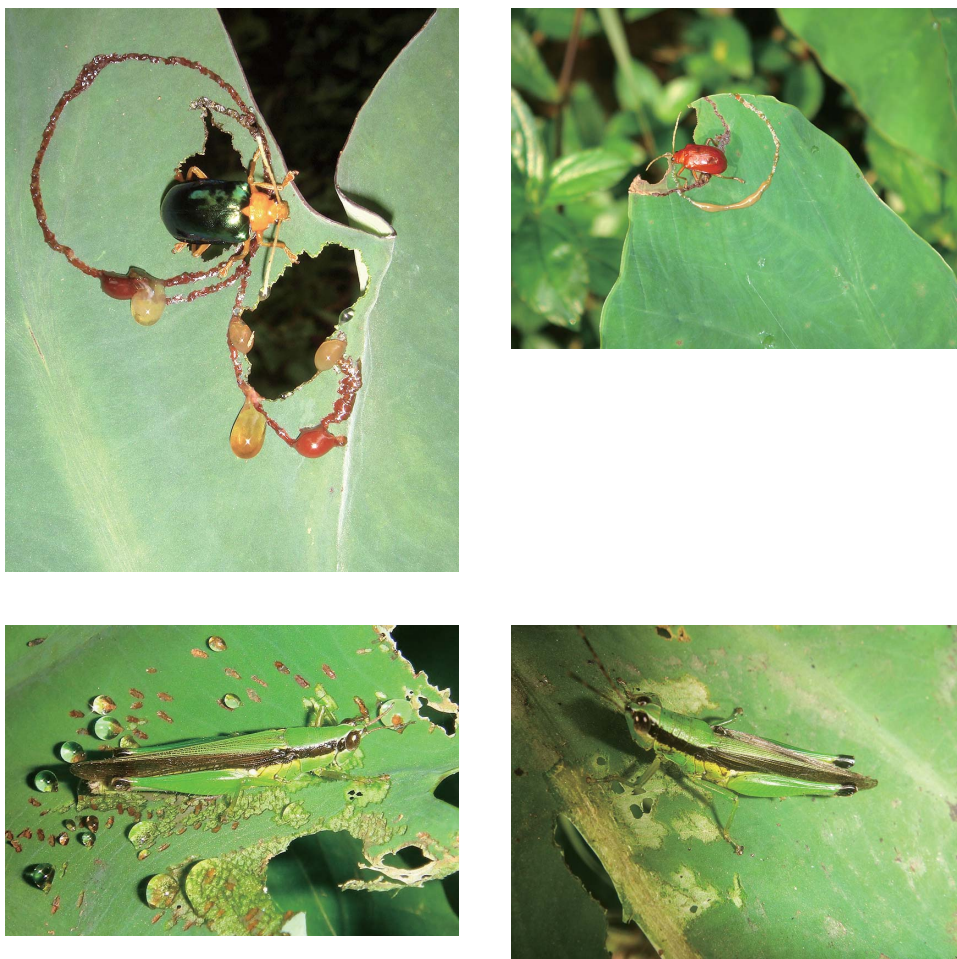
Near Lucban, Mt Banahaw, the following rules were given for preparing *laing*:

“To avoid itchiness, avoid making sounds when taking the first scoop [for eating]. This is just a story. Also, don’t use a lid when cooking; let the moisture out because itchiness goes out with the moisture; don’t stir too much while cooking, and don’t make too much noise while cooking.”



**Figure 8** Two popular dishes in which taro leaves are cooked with coconut milk and other ingredients. Upper: *pinangat*. Lower: *laing*.

Similar reports were found in food and cooking books published in the Philippines. Cordero-Fernando (1992) wrote at length on the itchiness of leaves in the Bicol region, after interviewing people in a variety of professions:



**Figure 9** Insects associated with wild taro in Luzon and Mindanao: (i) Leaf beetles: upper left, *Aplosonyx* sp., vic. Banaue, Ifugao, Luzon; upper right, red form? *Aplosonyx* sp., vic. Kidapawan, Mt Apo, Mindanao. (ii) Taro grasshopper, *Gesonula* sp. cf. *G. mundata zonocera* (Navas) Rehn (1952): lower left, Lake Sampaloc, near Mt Banahaw, Luzon; lower right, vic. Bansalan, Mt Apo, Mindanao. The beetles are c. 20 mm long, and the taro grasshoppers are c. 30 mm long.

'Every *gabi* eater's problem is how to tell if the *gabi* one has bought will irritate one's throat, since the *gabi* leaves, whether hanging dry upside down or bundled together green, do not exhibit any recognizable warning sign (This is strange because Bikolanos have been eating *gabi* for centuries.) Only the place of origin, they claim, can give a clue to its quality, but unfortunately, most *gabi* grow wild. My driver says that it's a gossipy cook who invariably produces an itchy dish. So does a noisy one. In order to have a non-itchy *gabi* dish, a teacher admonishes, the cook should not scratch any part of her body while cooking. A hairdresser insists that itchiness can be circumvented if you stir the *gabi* counter clockwise ... A grandmother advises

that drying the shredded leaves in the sun for an hour before cooking will kill the irritating substance ... A retired hospitality girl insists, however, that a simple stir-frying of the leaves in a bit of oil will do the trick. A nun in the struggle says all you have to do is remove the pointed tip of the *gabi* leaf since the concentration of itchy sap is all there' (ibid: 180–181).

An award-winning essay by Regala (2005) was devoted entirely to the description of her father's method for cooking *laing*. Great care was taken in the selection, harvest and handling of the leaves:

'... Then he tears each leaf into inch-wide strips, making sure he does so with a light, fluid motion. He said that a heavy hand can ruin the dish because that releases whatever it is that makes one itch after eating the cooked leaves' (ibid: 26).

Regala also compared the final consistency produced by young and tender leaves, in contrast to that produced more mature leaves: different people have preferences for one method or the other, but 'Young *gabi* leaves are also thought to cause more itchiness when improperly handled' (ibid: 27).

Laya and Lim (2006: 37) gave a different opinion regarding the choice of leaves, in their instructions for *laing*: 'When the *gabi* plant is very tall, the big wide leaves are not eaten as they are very itchy'. These authors also recommended that 'white-stemmed' *gabi* leaves be used for making *laing*, a preference consistent with the association between petiole colour, acidity, and selection preferences in Mt Banahaw survey (above). There may be no causal link between colour and acidity, but the link may be significant for recognising and selecting plants according to their acidity.

### 3.8 Insects Associated with Taro

In each area visited, taro plants were examined to check for the presence of insects, especially those that might be—or are known to be—closely associated with taro (Fig. 9). *Tarophagus* sp., a taro-specific planthopper in the family Delphacidae, was common on wild taro around Mt Banahaw, Luzon, and Mt Apo, Mindanao. *Gesonula* sp., a 'taro grasshopper' in the family Acrididae, was also common in these two regions. Large green leaf beetles (*Aplosonyx* sp., family Chrysomelidae), or the circular holes created by the feeding of these beetles, were common on *C. esculenta* in around Banaue and Mt Banahaw in Luzon. Similar holes were common on *Alocasia macrorrhizos* near Mt Banahaw, and rare on *Xanthosoma sagittifolium* (once, near Banaue). At Mt Apo, Mindanao, a large red leaf beetle very similar in shape and size to the green *Aplosonyx* sp., and producing similar circular feeding holes, was seen on wild taro at one location. Since we did not encounter any taro population with mature inflorescences, we were unable to determine whether or not specialist pollinators (*Colocasiomyia* spp., Takenaka 2006) are also present in the Philippines.



## 4. DISCUSSION

### 4.1 Remarks

To understand the origins and history of a crop, it is necessary to consider where wild populations of the same species were naturally distributed before people began interacting with them and using them. Ethnographic observation of how people use wild populations can also help by suggesting how wild plants were taken into cultivation, and how they were domesticated. Domestication, or the genetic modification of a useful species, requires selection from a variable population, and isolation of selected forms from the dominant genetic influence of a wild gene pool. Our survey has not proven the existence of natural, indigenous wild taro (*C. esculenta*) in the Philippines, but we can say that wild taro is abundant in some areas, whether or not breeding populations are present. We can also say that wild taro is economically significant, and is subject to loose management as a community resource. We have made some progress in learning about the ecology, dispersal, uses, and edibility. Circumstantial evidence makes it likely that wild taro is naturally distributed in the Philippines, and we will conclude by suggesting priorities for future research on the natural and cultural history of taro in the Philippines.

### 4.2 Wild Taro is Abundant in Some Areas

In the mountainous Ifugao region, in northern Luzon, wild taro (*C. esculenta*) did not appear abundant. This might be due to the very dissected nature of the terrain, which made access difficult, and the lack of large open habitats that are not closely controlled and cultivated. It is also possible that the cooler climate of this northern mountain region is not ideal for wild taro. On the dry slopes of Mt Arayat, further south, and in western Luzon, wild taro was completely absent. By contrast, wild taro was very abundant in open, wet, and humid areas, and at middle altitudes on Mt Banahaw and Mt Apo. Possible source populations may or may not be located at higher altitudes on these mountains, in less-disturbed and more inaccessible forest areas. The most common phenotype seen, from Ifugao to Mt Banahaw and Mt Apo, displayed green leaves, with white lower parts, relatively small corms, and long stolons. In all obvious respects, this is like the wildtype taro present in northern Australia, Papua New Guinea, Indonesia, Myanmar, and Vietnam—all areas where flowering and breeding populations are present (observations by Matthews, and others).

### 4.3 Wild Taro is Economically Significant

As noted in the introduction, Brown (1920) did not mention wild taro in his list of wild food plants of the Philippines. He did indicate that ‘personal judgment’ was used in making the list, and that: ‘Many people may consider some of those (plants) treated in the present list as worthless, and some common species which are omitted as good’, and that his list was ‘probably very far from complete’. In later publications, Brown (1941) and Monsalud *et al.* (1966) mention the use of other wild aroids, including species that are also cultivated, but make no mention of taro as a wild plant. From our own observations, and those of our local informants, it is clear that wild taro is widely used and popular as a vegetable food, mainly for the leaves, but also to some extent for the stolons, and as a source of leaves for pig fodder.

Cordero-Fernando (1992) stated that people in the Bikol region (southern Luzon) cook and eat only the leaves of the *gabi* plant, and that most *gabi* grow wild. We do not know if any attempt has been made to assess the commercial value of wild taro. In the past, wild taro may have been important as a source of starch in times of hunger, and as a free and nutritious leaf vegetable at all times, especially among rural households.

Despite the international use of taro as a leaf crop, most agricultural and genetic research on taro has been focused on cultivars that are grown primarily for their corms. Corms may have more nutritional or economic value, as a starchy food and for trade, in most social contexts. Pardales and Villanueva (1984) do not mention leaf varieties in their report on field trials with Philippine and Hawaiian cultivars at Baybay in Leyte. Lebot *et al.* (2004) surveyed the corm qualities of 2,298 taro accessions collected in Asia (including the Philippines) and the Pacific, and also did not comment on the use of leaves. In Vietnam, a national collection of 350 taro accessions included approximately 25 per cent with edible petioles or young leaves (Nguyen 2000). Wild and cultivated taros with edible leaves are likely to be under-represented in national collections of the Philippines and most other countries. To encourage further research on edible-leaf forms of taro in the Philippines, we collected several distinct forms of wild taro in the vicinity of Mt Banahaw (Table 1), and transferred them to a living taro collection maintained by the College of Agriculture, University of Los Baños.

#### 4.4 Loose Management as a Community Resource

Wild taro is widely used as a source of food and fodder in the Philippines, and is actively transplanted by people to suitable wild habitats. We are not able to estimate the frequency of transplantation, nor can we distinguish natural colonisation from transplantation when there is no local memory of transplantation for a specific location. In the common understanding of people who use wild taro, and recognise them as wild, the issue of transplantation may not be important. The most common distinguishing feature of wild taro plants is that they spread and propagate by themselves, vegetatively, in a wide variety of habitats other than privately cultivated gardens. Wild taro is treated as more-or-less a public resource, regardless of whether it is on public or private land, alongside roads and trails, or in unfenced fields and agroforest. When wild taro is on or close to private land, people who wish to harvest the plants are expected to seek permission, as a matter of etiquette.

Wild taro patches can persist for an indefinite period of time, if the harvesting intensity is balanced by regrowth and production of useful parts. Leaf yields must vary according to seasonal variation in leaf growth, differences in soil fertility, harvest frequency, and the number of people seeking wild taro leaves in each area. When only selected leaves or stolons are removed, the plants continue growing and continue to supply leaves and stolons. They might also spread laterally more quickly, in response to the loss of apical dominance, when leading shoots and stolons are cut. Wild taro varies in colouration, but all the forms seen by us produced stolons. This helps explain the local abundance of wild taro in many locations. Cultivated varieties that produce side-corms cannot spread so easily. We did see plants without stolons that may have been recent garden escapes, along roadsides and near gardens, but stolon-bearing wild taro was more obvious and abundant.

The management style of communities with abundant wild taro, around Mt Banahaw



and Mt Apo, can be described as loose, because the plants are available for harvest by anyone, and because they do not require constant replanting. At the same time, local people may have a keen interest in particular patches of wild taro, and may be harvesting them so frequently that the plants do not have opportunities to flower and produce fruit. This is indicated by the fact that most informants have not seen taro flowers (inflorescences). Although the management appears loose with respect to use and maintenance of the plants, it may be far from loose within the wider context of food production and supply, in upland areas where settlement density has increased in recent years. Maintaining wild taro populations as a community resource may be intentionally or unintentionally a way of increasing food security for all members of the community, and especially those with little land for growing their own food.

#### 4.5 Ecology and Dispersal

On one occasion, in the vicinity of Kidapiwan, Mt Apo, we met a villager who may have seen the fruit of taro, and birds eating those fruit. From the local name, *limucon*, and our photos, the bird can be identified as *Phapitreron leucotis*, the white-eared brown fruit dove. If fruiting of taro is common, in locations that are not frequently harvested, then this dove may have helped disperse taro, throughout lower altitudes in the Philippine archipelago. Taro fruiting heads consist of many berries, each containing numerous small seeds. Fruits, and especially berries, are the preferred food of this bird (Rabor 1977). The bird is common on many islands, from the lowlands to about 1000 m elevation. It is noted as an extraordinarily tame bird, and among Philippine members of the pigeon family, it is the species most commonly kept as a cage bird (ibid: 1977). The herbarium records cited above, and published reports (Merrill 1912b; Pardales 1981), show that taro flowers over many months, across the Philippines. In particular locations, the cycle of plant growth, flowering and fruiting is likely to be seasonal. Matthews and Naing (2005) concluded that in lower Myanmar, most flowering, pollination, fruit and seed development takes place during the rainy season (southwest monsoon). The present survey was conducted during relatively dry periods, so surveys conducted at other times of year are more likely to reveal whether or not breeding populations of taro are present in the Philippines. If endemic species of the taro pollinator, *Colocasiomyia* sp. are also found, then this would provide further evidence for the natural presence of taro in the Philippines.

Darling (2007) reported the presence of the leaf beetle *Aplosonyx ancora* on *Colocasia gigantea* in Vietnam, but it is not yet known whether leaf beetles in this genus have specific host requirements, at any stage in their life cycle. We did not attempt to identify, to species level, the taro planthoppers found by us, but two species have been reported in the Philippines previously: *Tarophagus colocasiae* and *T. persephone* (see review by Matthews 2003). These species are not endemic to the Philippines. Studies of genetic variation in this species might provide clues about the directionality of movements of cultivated taro, since the eggs and larvae of *Tarophagus* can be carried from island to island inside living taro stems.

An endemic regional form of the taro grasshopper, *Gesonula mundata* Walker, namely *G. mundata zonocera* (Navas) has been reported in the Philippines, from Mindanao (Rehn 1952). Our observations extend the range of this genus to Luzon. The colouring of this insect appears to be a camouflage that matches the colouring of taro leaves, especially after damage

caused by the insect itself, while feeding (Matthews, field notes, Philippines and Papua New Guinea). Indian authors cited by Rehn (1952) have reported that *G. punctifrons* in south India oviposited on the succulent stems of taro. *Gesonula punctifrons* has been noted as the most aquatic species of Acridoidea (Amédégnato and Devriese 2008). This and the only other recognised species of *Gesonula*, *G. mundata*, may have coevolved closely with wild, semi-aquatic forms of taro, in the wet natural habitats (Matthews 1997) of wild taro. Amédégnato and Devriese (2008) also note that a common adaptation of subaquatic species of Acridoidea is 'morphological and chromatic mimicry to the plant habitus', including adaptation of the ovipositor structure. The distribution of *Gesonula* species in Asia and the Pacific (Rehn 1952) almost exactly matches the natural range of taro suggested by Matthews (2006), but also extends to the Philippines. The association of an apparently endemic form of *G. mundata* with wild taro in the southern (and possibly central) Philippines, is perhaps the best indication so far that taro itself is naturally distributed in the archipelago.

#### 4.6 Acridity and Selection

The two most obvious or general differences between cultivated domesticates and wild wildtypes in taro are the reduced acidity, and greater starch production of domesticates. Increased starch production has arisen, in different taro lineages, through selection for larger mother corms, larger or more numerous side corms, and shorter, fewer or absent stolons. Internationally, there is great variability in the acidity and productivity of cultivated varieties of taro. Almost nothing is known about variability within wild taro populations, and among different forms of wild taro. The uncertainty that is expressed regarding the acidity of wild taro in the Philippines may reflect a combination of (i) variation in the skills of people who harvest and prepare the leaves, (ii) variation in how individuals react to acidity, and (iii) variation in the acidity of the plants as a result of interactions between taro genotypes and environmental conditions. There may also be uncertainty about the acidity of corms and leaves among cultivated varieties of taro, for all the same reasons.

Even in the absence of breeding, variation in a wild taro population may reflect the presence of multiple introduced clones, which may include a mixture of wildtype, domesticated, and intermediate forms. Selective dispersal and planting might favour clones that produce high leaf yields, that are easy to maintain, and that produce leaves of acceptable or better edibility. Whenever wild taro is discussed, researchers often ask how to distinguish between 'garden escapes' and 'truly' or 'naturally' wild taro. In the Philippines, the concept of a 'garden escape' does not seem to be of much interest among local people. The wild taro we saw in rural areas was always regarded as a useful wild plant. The wild plants may have a known or unknown history of being planted, or may have arrived in some locations by the natural dispersal of vegetative parts (or seeds) from other wild sources, or from gardens. Since cultivars in the Philippines also include forms with stolons, garden escapes with stolons might be positively encouraged by harvesting and replanting in the wild, and this could happen alongside the positive encouragement and replanting of stolon-bearing wildtypes and intermediate forms with edible leaves. Even the plants derived from gardens might soon be regarded not negatively as 'escapes' but positively as useful wild plants.

If breeding populations of wild taro are present in the Philippines, then plants that are

less frequently harvested in cultivated and wild habitats may occasionally interbreed, and become conduits for introgression between wild and cultivated taros. Favoured leaf varieties from outside gardens might also ‘escape’ into gardens by natural dispersal of seeds or vegetative parts, or by accidental or deliberate transplantation.

Cultivated varieties that produce only corms, without stolons, may be at a selective disadvantage in areas outside of cultivation because they cannot spread so easily as the leaf varieties with stolons. Effective dispersal of mother corms or side-corms within a particular location requires a deliberate planting effort. Without separation and replanting of corms, continuous harvesting of leaves would reduce the vigour of a taro patch. Corm-bearing garden escapes may also be of little interest as corm sources, as the quality of the corms is likely to be less than those produced in gardens with careful cultivation. The combination of strong interest in wild forms that produce edible leaves, and disinterest in garden-escapes that are corm-bearing domesticates may mean that (i) locally-recognized garden-escapes are relatively uncommon, and (ii) some wild clones have become more common and more widely dispersed than others. Over time, people may have transported many different clones of wild and cultivated taro into—and out of—areas where breeding populations exist, in the Philippines or other regions of Southeast Asia. This is especially likely if there has been a long history of using wild taro as fodder for pigs in Asia and the Pacific, a possibility suggested by Matthews and Naing (2005), and also by the 17<sup>th</sup> century observation of such use in Indonesia (Rumphius 2011).

From our interviews with farmers in the Philippines, it seems likely that *Xanthosoma sagittifolium* (commonly called ‘San Fernando’) has spread rapidly throughout the archipelago, since its introduction from the Americas. This spread maybe closely linked to its use as both food and as a fodder for domestic pigs. The plant may also have naturalised in many places through the discard of plant parts, especially the uncooked corm peelings with buds. Wester (1924) stated that there were ‘many varieties’ of recent introduction and limited cultivation’ We do not know if breeding populations are now present, but an illustration of this plant in the Philippines shows mature fruit with seeds, and was prepared with fresh plant materials (Brown 1941). Brown’s illustration of taro fruit (ibid) does not show developed seeds, but fruit with seeds were produced by cultivars in lowland field trials reported by Pardales (1981). The latter report makes it likely that fruiting and seed production will also be found in wild taro populations growing in wetter or more humid low-mountain environments, where conditions may be more suitable for insect pollinators. If natural breeding and seed dispersal are found to be common, then the genetic diversity of wild taro populations in the Philippines may be much greater than has been evident among cultivated taro varieties. If breeding populations are not present, then the genetic diversity of wild taro in the Philippines may be not much different from that of the recently introduced clones of *X. sagittifolium*.

#### 4.7 Agricultural History and Plant Domestication

Discussions of agricultural history in Asia and the Pacific have lacked the support of evidence in the form of archaeobotanical plant remains (Paz 2005; Denham *et al.* 2009). There has also been a general lack of biological research aimed at addressing historical questions. In the Philippines, it seems that there has been a long-standing and unquestioned assumption that

almost all crops present were domesticated elsewhere and introduced. Merrill (1912b, cited by Fox 1952) allowed that many fibre crops were of local origin, but claimed that 'Not a single important food plant or fruit tree originated in the Archipelago, but all have been introduced'. His view may have informed Beyer and Veyra (1947, cited by Fox 1952), who linked an imagined sequence of Neolithic immigrations with introductions of all the major root and cereal crops. In their scheme, taro, upland rice, and new varieties of yam were introduced to the Philippines by immigrants arriving in the period 1,500–500 B.C. Peralta (1981) noted the importance of root crops in relatively simple food production systems in the Philippines (among the Tasaday, Tau't, and I'Wak), and hinted that root crops (i.e., *Dioscorea* sp. and *Colocasia* sp.) may have formed a stable subsistence base that was present before the introduction of rice (see Acabado, this volume).

With regard to coconut, a major fruit and fibre crop in the Philippines, Harries *et al.* (2004) have argued that natural wild populations of this coastal strand plant were distributed throughout Southeast Asia during the Pleistocene period, including the Pacific coast of the Philippines, and that domestication required the transport of coconuts by people into inland habitats, where breeding and human selection could take place without a dominating influence from wild breeding populations. If natural wild populations of taro were also present along the wet Pacific coast, then the domestication of coconut may have coincided with the use of coconut as an ingredient for combination with taro, especially if using coconut in taro dishes helps to reduce the acidity of taro. The history of these two crops may be closely linked, since they have complementary roles in human nutrition. Harries *et al.* (2004) proposed a model for coconut that in many ways can serve as a model for the domestication of taro.

If the main habitat of wild taro is in wet and humid low mountains, in the Philippines, then human transport of taro into drier or cooler regions may have helped isolate selected forms of taro from wild breeding populations, establishing a process of local domestication that continues to the present. Genetic studies for coconut are more advanced than for taro, but taro may be an easier crop to study. Harries *et al.* (2004) concluded that wild and domesticated forms of coconut have been interbreeding and undergoing selection throughout the natural range of the species, making it difficult to recognise completely natural wild populations anywhere. In low-mountain regions throughout Southeast Asia, and in neighbouring tropical or subtropical regions, natural forms of taro (wildtypes) may still form dominant breeding populations. By studying genetic variation in wild populations, it may be possible to discover the genetic and geographical origins of at least some lineages of cultivated taro. Introgression between cultivated and wild taro populations is certainly possible, so we must also expect to find wild populations that are no longer completely natural, in genetic terms, despite being indigenous to the area in which they are located.

A number of crop plant introductions have helped transform agriculture in the Philippines in recent centuries (corn, sweet potato, potato and cassava among others), along with many changes in social organization. The present use of wild taro as a shared, common-property food and fodder source may be a very old way of using the plant, since similar common-property use was found in Myanmar (Matthews and Naing 2005) and in eastern Indonesia in the 17<sup>th</sup> century (Rumphius 2011: 291). Since the late 1940s, there has been general movement of small-scale farmers into upland regions throughout the Philippines (Kummer 1992),

as well as expansion of urban populations, and this may have had led to more frequent harvesting of wild taro in areas where it is abundant.

We cannot extrapolate from our observations directly into the distant past, but we can at least dispel the notion that there is no wild taro in the Philippines, and that human introduction is the only possible explanation for the presence of taro in the archipelago. If it is found that taro is an entirely introduced crop, we will still need to consider the possibility of secondary domestication, since the archipelago is physically and climatically well-suited for the spread and development of wild taro populations. The example of the *X. sagittifolium* in the Philippines makes it clear that rapid spread of an introduced root crop is possible, even if its dispersal is largely or entirely by vegetative means. This is also demonstrated by the introduction of taro into Florida, USA, where it is believed to spread by vegetative means only, and is regarded as an invasive weed (Meisenburg and Fox 2002).

#### 4.8 Future Directions

Our surveys to date have almost completely bypassed the most likely times and places for the flowering, fruiting and natural dispersal of taro. Where taro is distributed in wild breeding populations, it is likely to be an easily dispersed colonizer of forest gaps, assisted by birds and other animals in its dispersal—wherever gaps coincide with the presence of water, along stream banks, on waterfalls, and in the seepage areas of exposed slopes that form as a result of heavy rainfall, floods, typhoons, earthquakes and landslides. In the Philippines, all of these factors have the potential to coincide during the typhoon season along the earthquake-prone eastern side (Wong 2005) of the archipelago. The general instability of the landscape, and the abundance of water, make the eastern Philippines an ideal region, in principle, for the spread and development of wild taro populations.

In the Philippines, the frequent use of wild taro leaves as food and fodder provides an opportunity to investigate variation and selection in the qualities of leaf blades and petioles, and especially acidity, and to consider whether selection for leaf uses has been effective in creating domesticates that are distinct from those selected primarily for starch production. In China, Jianchu *et al.* (2001: Fig. 8) proposed that five main types of taro have been selected from wildtype taro: a thick petiole type with low 'acid' (acidity), multi-inflorescence type (with edible inflorescences), single-corm type, multi-cormel type, and multi-corm type. Great diversity in cultivated taro has been found in tropical and temperate region cultivars, so the crop is likely to have complex genetic and geographic origins. Close comparisons between wild and cultivated taros—in China, Southeast Asia, and Oceania—are needed to determine the genetic and geographic origins of the 'Oceanian' group of taro reported in the Philippines and Oceania (Lebot and Aradhya 1991; Kreike *et al.* 2004; Lebot *et al.* 2004). We hope that the present report will encourage further research on the natural and cultural history of wild taro in the Philippines, and its socio-ecological significance.

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