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Notes on the Provenance and Providence of Wildtype Taros (*Colocasia esculenta*) in Myanmar

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サトイモ野生種(*Colocasia esculenta*)の起源と利用にかんする考察

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The cultivated taro (*Colocasia esculenta*) is likely to have originated as a natural species in Southeast Asia, where most of its nearest wild relatives are distributed. Previous authors have noted wildtype taros in Southeast Asia, but little has been said about their habitat range, geographical distribution, and uses. Here we report results from an ethnobotanical survey of wildtype taros in central and lower Myanmar.

Wildtype taros in Myanmar are abundant and widespread, and the acrid leaves are very commonly cooked with broken rice as a fodder for domestic pigs. Less commonly, the leaves, inflorescences and stolons are eaten by people, after preparation in ways that remove most acridity. Although local residents almost always state that wildtype taros are never planted, the plants appear to be most abundant in the vicinity of human settlement.

The present close association between people, wildtype taros, and pigs may be significant for discussions of the domestication of taro and pig, and the history of agriculture in Southeast Asia.

サトイモの栽培種（*Colocasia esculenta*）は、その野生近縁種の多くが東南アジアに分布し、そこに起源すると思われる。従来の研究者たちも、東南アジアのサトイモ野生種に着目してはいたが、その生育環境や地理的分布、そして人による利用の形態については、ほとんど注意を払ってこなかった。この研究では、ミャンマー中央および低地でおこなった、サトイモの野生種に関する民族植物学的調査の結果を報告することを目的とする。

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Key Words：Colocasia, taro, pig, wildtype, domestication, ethnobotany, Myanmar
キーワード：サトイモ、ブタ、野生種、栽培化、民族植物学、ミャンマー

ミャンマーでは，サトイモの野生種が豊かにかつ広範囲に生息し，そのえぐ味のある葉は，くず米と共に煮られ，飼いブタの飼料として一般的に利用されている。それほど一般的ではないが，葉や花軸，葉鞘基が，さまざまなやり方でアク抜きされたうえで，人の食用に供される場合もある。住民によると野生のサトイモを移植することはないというが，サトイモ野生種がとくに集落の周辺に多く分布していることが観察されている。

こうした，人々とタロイモ野生種，そしてブタのあいだに見られる強い結びつきは，東南アジアでのタロイモとブタの栽化の問題を考えるうえで，重要な論点を提示するといえる。

1 Introduction

Taro (*Colocasia esculenta* L. Schott) is a basic food crop of great antiquity, and is widely distributed in temperate and tropical regions of the world. The plant is a strong candidate for early domestication in Southeast Asia and the Pacific, but archaeological evidence is generally lacking (Spriggs 2002, Denham et al. 2003).

Archaeological studies of many important crop plants have been helped by relatively easy preservation of hard seed remains in archaeological sites, and by ethnographic and ecological studies in cultivated, disturbed, and wild habitats. In the case of taro, a vegetatively propagated root crop, most research has been concerned with cultivated varieties (cultivars) that are generally assumed to be domesticates (i.e., selected types distinct from wildtypes). Very little is known about the variation, ecology, geographical range, and uses of wildtype taros.

In November 2003 and July 2004, the present authors surveyed wildtype taros in lower and central Myanmar, at altitudes from sea level to approximately 1,000 m above sea level. We found that the wildtypes are variable, abundant and widespread,

and occupy a range of obviously artificial to apparently natural habitats. Among these habitats, there is no clear dividing line between what is artificial or cultivated, and what is natural or wild. Recognizing the provenance or derivation of the plants in each location and population is not easy. Plants growing at the edge of a field or garden may or may not be self-sown and spontaneous. The wildtype taros are wild in their behaviour, with vigorous growth, abundant seed production, and rampant self-propagation by vegetative means.

To learn more about the provenance of wildtype taros *in situ*, we interviewed residents at many sites. Although wildtype taros are rarely planted (we learned of only one example of this), their leaves are commonly used as a cooked green fodder for pigs. In this role they are regarded by people as a free or natural resource, hence the reference to 'providence' in the title of our paper. Wildtype taros can also be used as food (for human consumption), but this is less common, or less economically important, than their use as fodder.

2 Natural and social context

Taro is one of several species in the genus *Colocasia* (Hay et al. 1995; Hay 1996; Long and Liu 2001), but only taro and *C. gigantea* are known as food crops. The latter is a minor stem vegetable with a distribution that is limited to eastern and southeastern Asia (Matthews 1991). The other species are restricted in their distribution to Southeast Asia, which is thus a centre of species diversity for the genus. Taro is therefore likely to have originated—as a natural species—within Southeast Asia. Wild and apparently wildtype forms range from India to southeastern Asia, eastern Asia, New Guinea, and northern Australia (Matthews 1995). Studies of isoenzyme variation in wild and cultivated forms of taro indicate the presence of distinct taro gene pools in Nepal, southern China, Southeast Asia and Melanesia (Lebot 1999, Yoshino 2002). The known differentiation of taro in these areas makes it likely that wild and cultivated taros in Myanmar are also diverse, through local diferentiation and also through natural dispersal or human introduction from neighboring areas.

Myanmar has a tropical monsoon climate, with cloudy, rainy, hot humid summers (June to September) and cooler, drier winters (December to April). Most land below 300 m altitude is cultivated, most areas between 300 m and 900 m are covered by various kinds of forest, and above 900 m there are large areas of grassland and evergreen oak forest (Kress et al. 2003). The country spans latitudes from 10 to almost 29 degrees N, and altitudes from sea level to 5,190 m. In the delta areas and inland river basins, wetland rice dominates the agricultural landscape. In the central dry zone, pulse, cucurbit, and oil-seed crops are important. In this zone, taro is rarely grown because it is a plant that requires abundant water. In mountainous areas, rain-fed cereal crops (rice, corn, and millets for example) are cultivated alongside root crops (taro, yams, cassava, sweet potato, potato and others). Bananas

are widespread, and useful trees are planted in and near villages everywhere.

Although traditional forms of agriculture are still widely practiced, there have been many changes in transport, water control, food production and food distribution, during and after the British colonial period (1826–1947). The large delta region, formed by the Irrawaddy and Sittaung rivers, was previously sparsely inhabited and mainly covered with swamp forest and grass plains. During the nineteenth century, large-scale clearing and water control projects began transforming the delta into a major rice-producing region. Many people migrated there from other parts of Myanmar (then Burma), and especially from the central dry zone (Adas 1974).

3 Previous records

Historical records of taro can be found in herbarium collections, in the place names recorded on maps, and in various books. Agriculture Corporation (1986) described wildtype and cultivated forms of taro in Myanmar and referred to earlier Burmese-language treatises on medicinal plants that we have not seen: *Kawiletkhana Kyan* (Sein Ta Kyaw Thu U Mya et al. 1961; in three volumes) and *U Du Baw Za Na Thin Ga Ha Kyan* (Yaw Min Gyi U Bo Hlaing 1961; original text 1870s).

3.1 Herbarium records

In 1984, herbarium collections of *Colocasia* species were examined at several herbaria in Europe (Matthews 1991). Three specimens from Myanmar (Burma) were found:

C. esculenta — collected by Dr Edward Bulkley, 1708. "Gathered in Pegu in the East Indies" Determined as *Colocasia esculenta* (L.) Schott by Dan Nicolson, 3 July 1962 (leaf blades only) (Edinburgh Herbarium).

C. esculenta — collected by C. E. Parkinson, at "Victoria Lake, Rangoon", 25th Sept. 1932, vernacular name "*pein ne*". 10–24 inches high, stem and petioles violet-black, spathes deep yellow. Collectors field no. 15101 (leaf blades, petioles, and an inflorescence) (Edinburgh Herbarium).

C. affinis — collected by C. E. Parkinson, 1932, at Prome Road, Rangoon; collection number 1,478 (Kew Herbarium).

Kress et al. (2003) noted that *C. affinis* is distributed in the Bago and Yangon divisions, and that *C. gigantea* has been reported (no reference given) from Myanmar.

3.2 Place names

On maps used in our survey, and during interviews, we learned about a number of place names that incorporated the standard Burmese-language vernacular name for taro (*pwin*). This name can refer to other wild or cultivated aroids in Myanmar,

but appears to refer primarily to taro. With regard to place names, we have not investigated other vernacular names for taro in the many local languages of Myanmar. Place names noted were:

Pein aing (depression with taro) — small settlement about 44 km northwest of Pegu city, at edge of hills on a small tributary of Pegu river; name shown on 1:250,000 scale map (sheet no. 94 C, Pegu, surveyed 1905–1929, republished in Japan).

Pein chaung (taro stream) — local name for a perennial stream emerging from Yezin forest, Mandalay Division; wild taro reported growing among rocks in stream at foot of hills, c. 5 km east of Shwemyo village, and c. 30 km south of *Pein in* (Shwemyo 9.11.03).

Pein daw (many taro) — village close to Tatkon town, Mandalay Division (Periplus country map, 1:2,000,000).

Pein gyaung (valley of taro) — lower Sittaung, east of Pegu city (Periplus country map, 1:2,000,000).

Pein in (taro pool) — a village 18 km southeast of Yamethin town, on bend of a stream near foot of hills; name is shown on 1:250,000 map (sheet no. 93D, Yamethin), surveyed 1919–1937 (republished in Japan, 1940s); wild taros reported growing there by residents of settlement 10 km west, on main road (vic. Yamethin, 28.7.04).

Pein ze lok (also transliterated as *Pone ze lok*) — small town at approximately 18°2′ N and 96°40′ E, in Bago District; the name is a transformation (into Burmese) of a previous Mon name for the same town, *Paw ze lawn* (place with much rice); so using the word for taro here has no obvious or special significance; the name switch is thought to have taken place hundreds of years ago (*Pein ze lok* monastery, 31.7.04).

3.3 Historical text and sketches

Wildtype taros appear in two sketches made in Yangon city in 1846 (Grant 1853). In one sketch we can see a large area of taro outside the decaying entrance of a Burmese fort (Yodega Gate), with low houses in the background (Figure 1). In other sketches, we can see taro growing in clumps alongside stilt houses that stand in water near Yangon river, and in the overgrown grounds of pagodas elsewhere in the city. Grant visited Yangon in August and September, during the rainy season, and described the taro as follows (our comments in brackets):

> "The whole of the ground about this place was literally one jungle of the *Kachoo* plant (an Indian name for taro), which here appears to grow wild and very abundantly. Though seldom brought into the Bazar as a vegetable, it is eaten by the natives. Those of which I have partaken here, have been very fine, and my host thinks, that were they properly cultivated they would not only form a good substitute for the yam (*Dioscorea* sp., presumably), but be superior to it. The potato (i.e. *Solanum tuberosum*) has not to

Figure 1 Taro growing 'wild and very abundantly' in front of Yodega Gate, Yangon, in 1846 (Colesworthy Grant, 1853).

his knowledge been either cultivated or tried in the country...." (Grant 1853, p. 46).

In sum, the previous records show that taro has been present in the vicinity of Yangon for at least 300 years (see Bulkley, 1708, herbarium collection), since before the agricultural and social transformations noted in our introduction. The references to taro (*pwin*) in place names also suggest that taro is a long-established element of the flora in Myanmar. Although there are much earlier botanical records of taro, in Asia and Europe, the sketches and text of Grant (1853) may be the world's first description of a wildtype taro population.

4 Survey aims and methods

Observations by H. Yoshino (pers. comm. 1998 and 2004) and M. Matsuda (pers. comm. 2003) encouraged the present author (PJM) to investigate taro in Myanmar. The survey reported here was carried out as part of the Myanmar Biodiversity Research Project organized by K. Watanabe (Tsukuba University, Japan), in collaboration with the Vegetable and Fruit Research Development Centre (VFRDC) and the Ministry of Agriculture and Irrigation (MOAI), Myanmar. Our aims were to investigate the phenotypic variation, habitats, abundance, geographical range, ecology, and human uses of wildtype taros.

During the first survey period (6–16 November 2003, early dry season) we observed taro as widely as possible, from lower to higher altitudes. During the second period (21 July–3 August 2004, mid rainy season) we filled in gaps along the route of the first survey, and spent more time in focus areas representing three different climatic zones: Yangon (wet, monsoonal), Yezin (transitional), and Mt Popa (dry).

4.1 Survey areas

Yangon (formerly Rangoon) is the capital of Myanmar, and has a dispersed urban population of about four million. The city is centered on a long, low ridge that extends from the central Pegu Yoma (Pegu Mountains) into the delta region, in alongside the Yangon river. The average annual rainfall in this region is about 2,500 mm. Food for the city comes from many parts of Myanmar. The corms of cultivated taro are commonly sold in the markets, but the main supply areas are distant. Yangon lies within the natural vegetation zone of tropical, wet evergreen forest, and the city itself has a remarkably green aspect, with an almost continuous canopy of trees.

Yezin district, in Mandalay Division, lies between the dry central zone of Myanmar, to the north and west, and the wet monsoonal lowlands to the south. In the vicinity of Yezin Agricultural University, perennial streams flow from forested mountains down to open agricultural lowlands alongside the upper Sittaung river. This district lies within the mixed deciduous forest zone.

Mt Popa is located in the central dry zone, reaches an altitude of 1,528 m, and attracts a relatively high rainfall of about 1,140 mm per year (the average annual rainfall can be as little as 600 mm elsewhere in the dry zone). Of the 111 natural springs recorded on Mt Popa, 36 are perennial (Popa Mountain Park information board, 2004). The mountain is a Pleistocene age volcanic cone, and is generally covered with tropical rain forest, in contrast to the dry forest and open cultivated or grazed lands that surround the mountain at lower altitudes. Several villages and monasteries are located on the lower slopes, near water sources. Our survey was carried out within Mt Popa National Park, which spans most of the mountain and is administered by the Ministry of Forestry.

4.2 Recognizing wildtypes

All the plants recognized as wildtypes had small corms relative to plant size (i.e. not expanded as in domesticated forms), long creeping runners (stolons), and strong acridity (as attested by local reports of inedibility or 'scratchiness').

In theory, some of the apparent wildtypes could have been clones that escaped from gardens, through vegetative dispersal, or could have been derived from cultivated plants though pollen or seed dispersal, or by the dumping of uncooked kitchen scraps. Many different interactions between useful plants and humans can be imagined (Matthews 1996). As an investigative starting point, we have assumed that if plants are (i) not planted, (ii) resemble wildtype taros seen in other countries, and are regarded locally as (iii) natural or wild, and (iv) inedible or poisonous, then they are wildtypes.

5 Survey results

5.1 Vernacular terms and phrases related to taro

gon pein — garden taro (Taung phego, 10.11.03).

pein — generic name for taro (the species or whole plant) and some other aroids; the name is used for wild and cultivated taro; according to Agriculture Corporation (1986), the word *pein* means to grow densely and uniformly, without any gaps; examples of other uses of this name are: *pein* = *Colocasia affinis*, *pein-gamon* = *Hayaline benthamiana*, *pein-kya* = *Caladium bicolor*, *pein pan* = *Amorphophallus purpurascens* (Kress et al 2003) (all in Araceae, the family of taro).

pein amay — taro mother (mother corm) (Taung phego, 10.11.03).

pein kya phet twin ye ma hte — water does not stay on the taro or lotus leaf (may all danger coming to you go away).

pein pin — whole taro plant (Yezin, 14.11.03).

pein swe — taro stolon (Yangon 6.11.03)

pein thangal (*khine mae* in Shan language) — taro baby, the side-corm (Taung phego, 10.11.03).

pein u (*pein oo*) — general name for cultivated taro, and also for the edible corm of cultivated taro (*u* generally refers to a starchy root, tuber or corm, but originally means 'egg'; *kyut u* = the egg of a chicken).

pein u yine — forest taro (an entirely green local wildtype) (Yezin village, 14.11.03).

ye pein — water taro (a local wild taro, Taung phego, 10.11.03).

5.2 Distribution

Wildtype taros in lower and central Myanmar are abundant, widespread, phenotypically variable, and occupy a range of obviously artificial to apparently natural habitats. Our survey route is shown in Figure 2. Observations of distribution were made from a car, site visits, and interviews with local inhabitants. A slow driving speed was maintained in order to allow continuous observation and frequent stopping. The leaves of taro are large and highly distinctive and can be easily recognized from a moving vehicle. More intensive investigations, by car and by foot, were made in the vicinities of Yangon city, Yezin, and Mt Popa.

Yangon city

Wildtype taros are ubiquitous in Yangon city, wherever drains and depressions hold moisture. They are most abundant around the shores of artificial and natural ponds and lakes, and along streams or ditches that run through vacant land. The plants are usually entirely green. They are absent on dry ground on the broad ridge that descends through the city towards the southeast. On the eastern side of Yangon

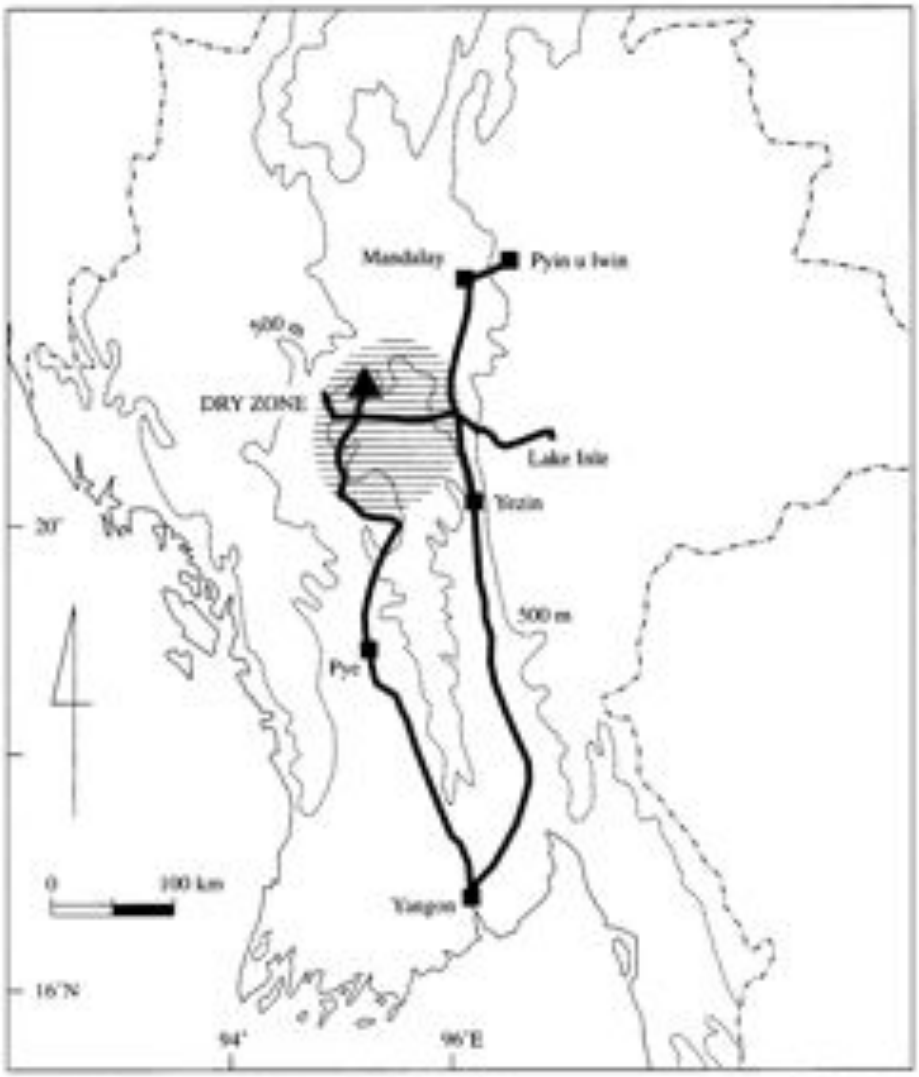

Figure 2 Survey route in Myanmar (2003–04). Wildtype taros were abundant in wet lowland and mountain areas outside the dry zone, and on Mt Popa inside the dry zone.

river, the same ridge descends to near sea level in the city of Kyauktan. At Yangon and Kyauktan, the river is tidal with fresh water at the surface. Next to Kyauktan, the village of Ngwe thaung yan ('silver beach'), is situated on the level top of a sandy river bank that is flooded each day at high tide, during the rainy season. The green wildtype taro was found there in occasional clumps or patches, and was said by residents to be spontaneous and never planted.

Figure 3 Wildtype taro alongside Yangon river, near the former site of Yodega Gate (July 2004).

In Yangon city, enquiries about the location of Yodega Gate (Figure 1) led us to the vicinity of Botataung Pagoda and an adjacent pier on Yangon river. Green wildtype taros were found alongside the main strand road, and among other herbs and organic flotsam in the riverbank flood zone (Figure 3). In theory, this area could have been washed out by floods, and recolonized by taro parts floating in the river (corms, stolons, and perhaps seeds). It is also possible that there has been continuous self-propagation *in situ* since Grant's first observations in 1846, 158 years ago (Grant 1853).

Yezin

Green wildtype taros were first found in damp ditches on the campus of Yezin Agricultural University, and along a rocky stream course in the adjacent Yezin village, below a large dam and water reservoir that was completed in 1975. Wildtype taros were later seen among tall grasses on soft banks of a stream (Tan pin chaung) above the reservoir, in upper Yezin district. The stream is perennial and emerged with a strong flow from the nearby hills. From farther observations and interviews it appears that wildtype taros are common alongside perennial streams in the mountains near Yezin. They are occasionally present in wet lowland locations to the north of Yezin village (towards the dry climatic zone), and are increasingly common in lowland areas to the south (towards the wet climatic zone).

Figure 4 Wildtype taro among rocks in a perennial stream at Mt Popa (July 2004).

Mt Popa

On Mt Popa, wildtype taros were found only in association with permanent springs and the perennial streams below them (Figure 4). The springs are common at an altitude of about 500 m, around most of the mountain. We visited sites near Popa village, and further sites were reported by our experienced local guide (Figure 5). In general, the wildtype taros here are used as pig fodder, but not every patch is used in this way. Many of the plants we saw were tall (uncut) and displayed flowers.

Taro-specific insects (plant hoppers and pollinators) were also seen, and this leads to the question of how and when the insects reached the isolated Mt Popa taro population. The mountain is surrounded by dry country with no suitable habitats for taro. Further study is needed to determine whether the Mt Popa plant and insect populations are relicts of earlier continuous distributions, during a wetter climate regime, or the result of more recent dispersal from distant populations. If the surrounding dry zone is a barrier for seed dispersal and for the insects, then this might suggest an ancient origin and relictual status for the plant and insect populations. If the insects are easily carried by wind, over long distances, but seeds are not carried long distances by animals, then it may be only the plant population that is relictual.

5.3 Phenotypic variation

In most areas visited, entirely green wildtypes (Figure 6 a, c) were most common, and these resembled, in their vegetative characters, a tropical lowland wildtype

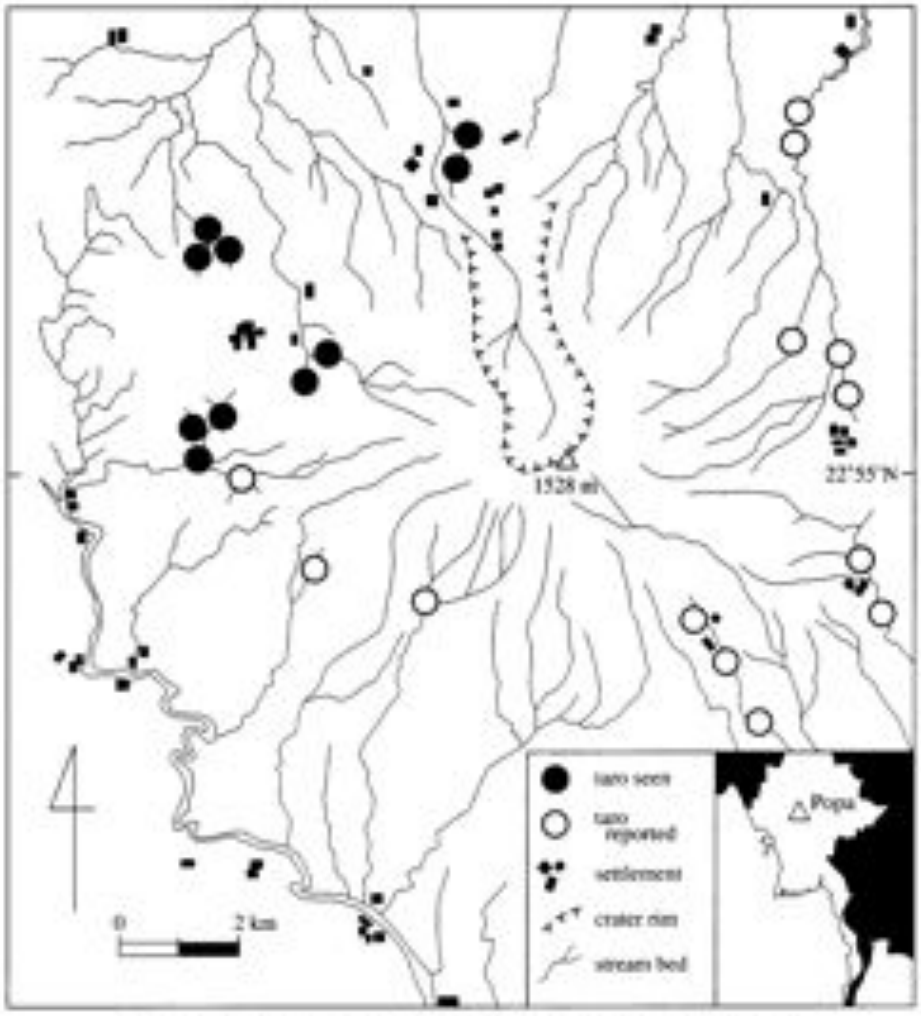

Figure 5 Wildtype taro sites at Mt Popa National Park (next to stream lines).

found elsewhere in Asia and the Pacific (Matthews 1991, 1995, 1997; Matthews et al. 1992; Hay 1996). Other putative wildtypes displayed bronze to purple or near black petiole colours, purple stolons, and in one instance, branching stolons (Kyauk than bud, 30.7.04). The inflorescences also varied in coloration, overall size, and internal proportions.

The occasional presence of atypical phenotypes in lowland Myanmar may reflect natural dispersal and/or introgression from higher-altitude wildtype populations into lowland areas. Alternatively, some of the variation may be the result of crossing between cultivated and wild taros. Despite variation attributable to local differences in exposure and substrate, the wildtype plants (Figure 6b) at Mt Popa

were phenotypically uniform. The plants had a graded purplish to bronze and green petiole colour, and were distinct from the entirely green wildtypes seen at Yezin, Yangon, Inle, and elsewhere.

5.4 Insect associates

Pollinating flies (c.f. *Colocasiomyia* sp. Grimaldi 1990, and formerly known as *Drosophilella*), pollen-collecting stingless bees, and sap-sucking plant hoppers (possibly *Taraphagus* spp.) were found on taro inflorescences at many locations, but not usually all at each location. Specimens have been collected for later identification and analysis. The pollinating flies were only seen during the second survey period, in the rainy season, and this is consistent with the view, expressed by many people interviewed, that the main flowering season for taro is the rainy season (see next).

5.5 Flowering, pollination, fruit and seeds

Taro produces male and female flowers on the same plant, in separate positions on a long, more-or-less vertical spadix, inside a specialized leaf blade (spathe), and raised on a specialized leaf stalk (peduncle).

During both survey periods, we found many wildtype taros with inflorescences, but it was only in the second period, in July, that we found pollinating flies, and fruit with seeds at various stages of maturity (Figure 7). From our observations and interviews, it appears that most flowering, pollination, fruit and seed development take place during the rainy season, in lower Myanmar. The rainy season starts between mid-May and mid-June, and is also known as the southwest monsoon (with winds mainly from the southwest). The northeast monsoon is dry, and is the cool or winter season.

In the delta and Sittaung river region, from Yangon to Yezin, a few early-flowering plants were seen in July 2004, but local informants consistently reported that flowering begins or peaks in August or September. Overall, at relatively low altitudes (below 1,000 m) and between the latitudes of 16–22° N, there was no obvious geographical trend in flowering dates. The dates vary within and between populations, and the timing of peak flowering at any particular location may depend on many factors (rainfall, humidity, temperature, soil conditions, plant genotype, and leaf harvesting intensity).

We did not see loose seeds or young seedlings, but the seeds are very small (about 1.0 to 1.5 mm long), and we have not searched for them intensively. The best time to search may be at the end of the rainy season (late October) or soon after, which is when seed may be dispersing or beginning to germinate. While many of the people we interviewed could describe the flowering of taro, we did not meet anyone who could describe the fruit or seeds in any detail. Deliberate propagation by seeds was never reported.

Natural dispersal pollen and seed is likely to be common in Myanmar. In July

and August 2004, we saw abundant pollen, pollinating insects, and fruiting heads with seeds at various stages of development. Each fruiting head contained hundreds of seeds, and at least one likely dispersal agent, the common palm civet, is present in Myanmar.

Hamballi (1980) reported dispersal of taro seed by the common palm civet (*Paradoxurus hermaphrodites*), in Indonesia. This civet is an omnivorous mammal and is also found in the mainland of Southeast Asia, from India to southern China (Francis 2001). The ripe fruit of taro may also be attractive to birds, being brightly coloured, and sweet (a very small piece, masticated on the tongue tip, produced a sweet and slightly acid flavour with no apparent acridity) (PJM at Pye, 23.7.04). In principle, it is possible that fruiting heads, detached fruit, and detached seeds are dispersed in water, but detachment of the entire fruiting head has not been seen, and detachment of fruit from the spadix is most likely achieved by animals that feed on the fruit. Seeds that have passed through an animal gut might be dispersed in water subsequently.

5.6 Vegetative dispersal

Long stolons (lateral runners) are a defining character of the wildtypes discussed in this paper. Multiple stolons are produced by each parent plant, and the parent plant itself is usually firmly anchored by roots. Three modes of vegetative dispersal were seen or can be inferred:

Horizontal extension by stolons

The stolons extend across soil or rocks, for up to a few metres, while still connected to the parent plant, and new vertical shoots with roots and leaves sprout from the nodes. Eventually the internodes rot or break, and the new shoots remain in place, anchored by their own roots.

Stolon relocation

At some sites, the stolons extend into water, and even nodes that sprout roots and a shoot are not anchored. Through decay and/or water pressure from a stream or a flood, the stolons are broken and pieces with nodes are released into the water course; when caught at a suitable location downstream, the dislodged pieces take root and form a new clump of taro. Taro stolons are sometimes brittle and easily snapped, and in situations where the plants are often disturbed, this might lead to a vegetative form of 'shattering', a term usually applied to the ready shedding of seeds by many grass species. Variation in the abscision or breakage of stolons has not been studied in detail.

Entire plant relocation

Entire plants and small patches of taro may be washed away by floods if they

Figure 6 Wildtype taros, with small corms and long stolons, from three different locations: (a) Yangon (entirely green leaves), (b) Mt Popa (leaves with some purple to bronze colour on the petioles), (c) 'Taung pein' (mountain taro) at Kyauk than bud, near Yezin (entirely green leaves). Scale = 10 cm.

Figure 7 Fruiting heads of wildtype taro, taken from one plant (Pye, July 2004). From left to right: mature inflorescence with yellow upper spathe; inflorescence with withered spathe (after pollination); fruiting head after the upper spathe has dropped; fruiting head with lower spathe removed to show immature green berries; fruiting head with lower spathe removed to show mature orange-red berries. Scale = 10 cm.

Figure 8 Wildtype taro patch established by planting, in front of a family compound (Pyesok, July 2004).

Figure 9 A pig reared using wildtype taro leaves as fodder (Pyesok, July 2004).

Figure 10 Wildtype taro leaves harvested for pig fodder, then carried along road towards a village (Sittaung valley, July 2004).

are growing on soft substrates that are easily eroded (on muddy stream banks, for example). This process is inferred from the fact that taro plants are often located on soft banks.

5.7 Association with settlements, and dispersal by people

In lower Myanmar, wildtype taros are widely dispersed in the countryside between settlements—in wet roadside ditches, and other natural or artificial watercourses. They are not seen in places that are completely dry in summer, nor in wet areas where constant grazing by cattle and other domestic animals prevents establishment. In places where taro is already established, it is not touched by grazing animals and appears to form stable populations.

Although wildtype taros are widely dispersed in areas between settlements, they are most obviously abundant in and around rural villages and towns, and in the entire urban area of Yangon. Local residents were questioned at many locations, and with just one exception we were told that the wildtype taros are wild, or grow naturally, and that they are not planted. Most wildtype taros grow in positions that are not privately owned or controlled, and are not planted, or are not remembered as having been planted. This may explain why they are generally considered to be a public resource, that anyone may harvest when available and as needed.

In only one place, members of one extended family told us that they had planted taro (a local wildtype) to provide leaves for their own pigs (Pyesok, 31.7.04). A vigorous and apparently permanent taro patch was thus established in a ditch in front of the fence enclosing a family compound (Figure 8). The compound had four raised houses, each with one pig underneath (Figure 9). Leaves for the pigs are also obtained from other wildtype taro sites in the area. The pigs are only given taro until the age of ten months because the leaves require long cooking, and older pigs require more food. To remove acridity, the taro leaves must be cooked (together with broken rice) for approximately 30 minutes to one hour (depending on the quality of firewood), and the supply of firewood is limited. To avoid using too much wood, other greens that require less cooking are given to the older pigs. The taro leaves are mainly fed to young pigs, and help them to grow quickly.

Since most people do not recall ever planting wildtype taros, such planting is probably not frequent. It might only occur when there is rapid expansion of a settlement into an area where taro is lacking. Once established in a settlement (whether by natural means or after being planted), wildtype taros might form permanent populations and continue to spread naturally.

5.8 Wildtype taros as fodder

The use of wildtype taros as a green fodder (*ayu sein*; lit. 'food green') for pigs was known wherever we found the wildtypes during our survey. In the settled agricultural regions we visited, most wildtype taros are used in this way (Figure 10).

For faster replacement of the leaves, and a better yield, the best harvesting time is in the second half of the rainy season when the plants are large and vigorous. During this period, new leaves emerge just a few days after cutting (Pyesok, 31.7.04). Alternatively, wildtype taro may be cut mainly during the dry winter season, when other fodder is less abundant (Mt Popa, 26.7.04). Leaves (each consisting of a tall petiole with blade above) are the generally stated target for harvesting, but inflorescences (each consisting of an upright peduncle with spathe and spadix above) are probably also collected, together with the leaves. In urban areas, wildtype taros are also cut to keep ditches and street edges clear. This is the main reason for cutting wildtype taros inside the capital city, Yangon, where pig raising has been officially banned for many years.

Many people stated that when taro leaves are cooked with broken rice, their pigs grow quickly, and that the mixture is very good for pigs.

People (and their pigs) can recognize variation in the acridity of wildtype taros. At Aung min galar (31.7.04), purple and green-stemmed wildtypes are abundant, but only the latter is used as fodder because the pigs prefer it, the purple-stemmed type being more scratchy (acrid). At Lake Inle (12.11.03), one family told us that they stopped feeding wildtype taro to pigs about twenty years ago, after noticing that the pigs were irritated around the mouth. The pigs were biting on the wood of their stalls for relief, and also had diarrhea. A different aquatic plant is now used as a green fodder (possible reasons for the symptoms described are that too much taro was used, relative to other fodder components, or that the taro was not cooked for long enough). A need for habituation also indicates that wildtype taro is not entirely pleasant for pigs: if wildtype taro is provided when a pig is young, the pig will eat taro all its life; if not, then the pig will later refuse taro (Yeni, 31.7.04). Only a single observation can be cited here, so the need for habituation in pigs is not necessarily universal, with respect to taro. The apparent need for habituation might vary according to the acridity of each wildtype, and the details of how fodder is prepared, and might even reflect a more general psychological preference for familiar foods, regardless of their edibility.

In general outline, the methods for preparing wildtype taro for pigs do not vary much: the plant is always chopped and cooked, and is always presented as part of a gruel or slop. The following methods were reported:

Method 1: Cut taro leaves (blades and petioles together) into pieces, mix with broken rice, then boil about 30 minutes. This gruel is mainly prepared for pigs. It can also be given to ducks, but not to chickens (Yezin, 14.11.03). Rice bran is often (or usually) added, before or after cooking the taro and broken rice. Although broken rice is cheaper than table rice, it is still too expensive for some people, and can be omitted (see next).

Method 2: Chop the green leaves, mix with rice bran and the oil cake left over from pressing peanuts (Taung phego, 10.11.03).

Rice bran is a modern side-product of making white polished rice. Internationally, its production has followed the rise in popularity of white rice. Rice bran has very good nutritional qualities, but is difficult to store for long periods. It has a high soluble fat content and quickly becomes rancid and unfit for human consumption (Malekian et al. 2000). It is used in fodder mixtures in many countries.

Other sources of fodder for pigs in Myanmar include the vines of *Ipomoea aquatica* (wild in ponds and ditches), *Commelina* spp. (*wet-gyar*, common weeds), and various cultivated plants: the inner stem (pith) of banana, unspecified parts of amaranthus and sorghum, and the residual oil cakes produced when various oil seeds (castor, peanut, sesame) are pressed for oil (Mt Popa, 25.7.05, and other locations). Our enquiries regarding other sources of fodder were not exhaustive, and each source may have its own particular importance, in ecological, economic, and nutritional terms.

5.9 Wildtype taros as food

At most wildtype taro sites where people were encountered, in or near settlements, the plants were recognized as having at least one part that can be eaten. We did not witness preparation and consumption, but after many interviews it became clear that the most commonly used parts are petioles and young inflorescences. The use of wildtype taro corms was mentioned only once, by a retired town official who stated that he had heard of them being eaten in the past, that they are eaten less often now because better foods are more plentiful, and that some poor people may still eat them (Taikkyi 22.7.04).

When enquiries extended to more than one person or household near a particular taro site, different people reported different methods of preparation, regarded different parts as edible, or did not regard any part as edible. In one village, we learned that a residual bad effect (i.e mouth or throat irritation) can be felt even after cooking the plant in the locally accepted manner, so only some people actually use the plant.

Whether or not wildtype taro in a particular area is eaten now must depend on variation in the inherent food qualities of different wildtypes, the culinary knowledge and food tolerances of people in that area, whether or not people have had experience of it as a famine food, and the availability of other foods. While some people may enjoy wildtype taro as a vegetable regardless of economic circumstances, others may regard it as a famine food only, i.e. as a food of last resort.

Uses also vary from season to season. In places with sufficient water, the plant can grow throughout the year, and the petioles are always available. However, leaf size, flowering, and plant growth rate all vary according to season, and some people expressed preferences regarding the maturity of the plant parts used. The eating of stolons was indicated in only one interview, with reference to a pale-green wild-

type with long and branching stolons (Kyauk than bud, 30.7.04). Stolons (*pein swe*) from wildtype taro were subsequently found for sale as a vegetable at the Hledan market in Yangon (KWN, October 2004). The fruiting head of taro, which remains and develops after the upper spathe has withered, was never mentioned as a food or fodder. The cooking methods indicated in Table 1 are described below. Simple categorization of the dishes is difficult because for most of the dishes, more than one kind of treatment for acridity is employed. Acridity or perceptions of acridity are likely to be reduced by all of the following: boiling, frying, baking, salting, acidifying, sweetening, thickening with starch, cutting, mashing, and drying. The edible parts of wildtype taro are illustrated in Figure 11.

Boiling

Petioles can be cut and then boiled in two ways (Taikkyi, 22.7.04):

Method 1: Boil petiole, then peel the skin.

Method 2: Peel the skin, then boil. While the petiole pieces are cooking, add salt and sesame powder for flavour, according to taste.

Salting

To prepare petiole or peduncle of mature leaf or inflorescence: (a) remove the skin by peeling, (b) cut into pieces, (c) mix pieces with salt and let sit for 5–10 minutes, then wash with water, (d) add some rice flour to water and boil (i.e. to thicken) (this can be done while peeling and cutting the taro), (e) add a little oil and onion to frying pan, and stir thoroughly, (f) add the liquid and taro pieces, and cook for about 10 minutes. The salt helps remove the scratchiness, which disappears (Swa, 31.7.04)

Sour soup (acidification)

Method 1: To prepare the young stem (petiole): (i) peel, (ii) break it into pieces, (iii) bring water to boil, add fish paste, then add taro pieces and further vegetables, including roselle (*Hibiscus sabdariffa*); the latter makes the soup sour; add salt to taste. This is a main soup that goes with rice; it is best eaten in summer (March to May) but can be made at any time (Inle, 12.11.03).

Method 2: To prepare spathe (green or yellow stage) or peduncle: (a) chop without peeling, (b) boil together with tamarind (*Tamarindus indica*) leaves and discard the water, (c) cook again in a soup. The taro leaves are not eaten (Pyeok, 31.7.04).

Method 3: To prepare the very young rolled leaf, or young spathe (green stage) (a) chop the taro into pieces, (b) boil in water for one hour together with the leaf of *kinbalin* (*Antidesma* spp., small trees; see Kress et al. 2003; also known as medicinal plants in Myanmar). The *kinbalin* leaf is sour; other flavours can be added according to taste (Yezin, 14.11.03).

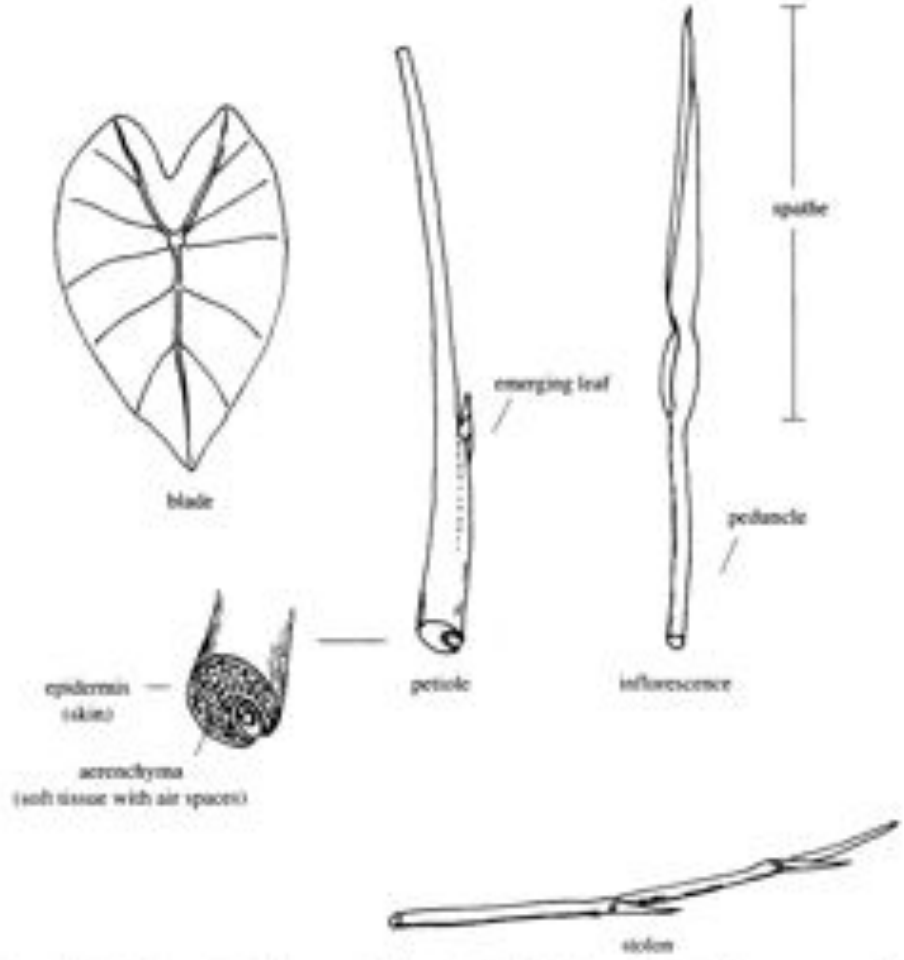

Figure 11 Edible parts of wildtype taro in Myanmar. The leaf (blade and petiole) inflorescence (spathe and peduncle), and stolon (lateral runner) grow from an inedible central corm (not shown). The entire inflorescence (flowering organ) looks like one flower, and is commonly referred to as such, but the actual flowers (male and female) are attached to a spadix hidden inside the spathe, which opens to allow pollination by insects.

Curry (frying in oil)

Method 1: To make a thick main dish, or curry, called Pein pwint hin ('taro-flower chilli'), harvest the peduncle and spathe when the latter is turning yellow; the two parts are cooked and eaten together: (a) initial preparation was not described, but presumably the taro is chopped, (b) the taro is cooked with onions, pork, and soybeans in peanut oil, (c) for flavouring add salt, a little chilli, garlic, and ginger. The flowers mainly appear in June and July, during the rainy season, and taste best

when the spathe is turning yellow; some people sell the flowers in the market, but most people pick them for eating themselves (Inle, 12.11.03).

Method 2: Recipe outlined by a Yangon city relative of the author (KWN,16.11.04): (a) fresh stolons are boiled, and water is decanted. (b) stolons are cut into pieces (three inches long). (c) fish, fish paste, peanut oil, pepper, onion and garlic are added. (d) water is added and the mixture is boiled for a few minutes. Note: this dish is classified as a 'curry' here because cooking in oil with flavourings is a defining characteristic of a Burmese curry; many 'curry' dishes in Myanmar do not use spices in the Indian manner (Khaing, no date:12).

Leaf Blades (mash or dry)

Method 1: Fresh leaf blade is prepared as follows: (a) boil blade to soften, discard water. (b) pound entire blade, veins and all, together with chillies and salt (some people also add the small-fruit of *Solanum indicum*, a native relative of eggplant; with toxic seeds that require removal according to Mabberley, 2002). (c) wrap the mashed material in a banana leaf, and bake the bundle in hot ashes for 15 to 20 minutes. This method is not used for cultivated taro (Taung phego, 10.11.03).

Method 2: Reported by a resident of Kyauk Me, Northern Shan State, to KWN (November 2004): (a) leaves are sun dried for one hour. (b) each leaf is broken into three or four pieces. (c) ripe tamarind fruit or pickled bamboo shoot is added. (d) jaggery (unrefined palm sugar) is added. (e) water is added and the cooking pot is gently heated: complete cooking requires four to five hours.

Drying petioles

The production and sale of dried petioles from wildtype taros was established as a trade by a retired professor of agriculture (former teacher of the present author, KWN), some years ago after buyers for the product were found in Korea. The trade began at Inle ('lake of four villages'), where wildtype taros flourish alongside wild grasses along the shore and along the edges of floating gardens (large beds of compost and soft soil held together by bamboo stakes, and plant roots, and extending into the lake). On the northern side of Pye city (Prome), wildtype taro is also abundant in wet areas, and petioles there are also harvested and exported to Korea.

At Inle, long mature petioles are cut, peeled, split lengthways, and then hung on strings to dry (and shrink) at ambient temperature, in shade. The dry petioles are then tied into bundles for sale to traders who export the product. Local observers and participants in the trade are generally not sure how the petioles are eventually used, but the most likely uses suggested are as an ingredient in soups, or as a substitute for meat in meatballs.

The peeling, drying, storage and cooking are all steps that may reduce acridity enough to make the petioles edible. The consumption of fresh and dried petioles

from cultivated taro is widespread in Asia (from Nepal to China, Korea and Japan at least), and fresh taro petioles (from wildtype and cultivated taro) are also eaten in Myanmar.

Cultivated taro

In lower Myanmar, taro is generally cultivated on only a very small scale, and perhaps mainly for home consumption. National and regional level statistics on taro production and consumption are not available. There are no obvious environmental reasons for this. One cultural reason may be unfamiliarity with growing the plant, among descendants of relatively recent migrants from the central dry zone. The corms sold in Yangon are mainly from southern Shan State, but some also come from the delta region (Yangon city market interview, and U Kyaw Win, pers. comm. 2003).

In western Magwe Division and in the few mountainous locations visited (Pyin u lwin, Aungban, and near Yezin), we met farmers with expert knowledge of growing taro. Scraps that are discarded during preparation of corms for human consumption are also fed to pigs (presumably after cooking). The corm apex and attached petiole base are discarded and fed to pigs (Aungban, 12.11.03), and are likely to be more nutritious than corm peelings.

6 Conclusions

Wild or wildtype taros have been reported as pig fodder (or simply as 'fodder') in a few countries, but not in any detail: China (Yongping and Jianchu 2000), Japan (Matthews et al. 1992), New Guinea (Hide 2003: 76), New Zealand (Matthews 1985), and Vietnam (M. Matsuda pers. comm. 1999). In northern Thailand, the leaves of taro (source not stated) are also fed to pigs (Anderson 1993: 60). The widespread links between taro, pig husbandry and human subsistence could be ancient, or could have developed relatively recently in response to increasing overall demand for food and fodder sources. Neither possibility can be excluded with the sparse ethnographic and historical data available. Here we will focus on the provenance and providence of wildtype taros in Myanmar.

6.1 Provenance

One connotation of the term 'provenance' is 'derivation'. Confusion arises about the meaning of 'provenance' because 'derivation' can refer to anything from the collection process (where a sample came from), to more difficult questions about the natural and social origins of a plant (how and when it came to be in a particular collection site or area).

In agricultural research, recording provenance is often simply a matter of noting the geographical location (place name, map co-ordinates), habitat (wild or

cultivated), and other details of the immediate environment of a collected sample. In historical research, the provenance of a plant can never be fully known because the past is open-ended. When we look back in time, 'provenance' has no spatial or temporal limits. Of course arbitrary and practical limits are imposed by the limits of our perceptions and research methods.

In Myanmar, previous experience (Matthews 1997) provided a starting point for recognizing wildtypes independently of habitat. During our survey we looked for wildtype taros in as many different situations as possible, in wet to dry areas, lower to higher elevations, and in wild to cultivated habitats. We then investigated provenance by seeking information on uses, deliberate planting, natural dispersal, and recent historical changes in the local environment. In this way, we could begin learning to what extent the wildtype taros are naturally distributed and to what extent people are involved in their dispersal.

Special attention was given to the sources, distribution and management of water because taro is highly dependent on water for its growth and natural dispersal. We also gave special attention to signs of human interference (primarily the harvest of leaves), vegetative self-propagation and spread by the plants, flower, fruit and seed production, and associated insects (especially those that may be important for pollination, or that may have differentiated as host-specific species in Myanmar).

In agricultural research, the term 'wildtype' is usually used to indicate plants that have not been affected in their genotype or phenotype by human interference and selection. In fact it is impossible to exclude all possibilities, over thousands of years, of human influence in the history of plants that now appear to be wildtypes. All that can be established is a continuing, iterative research process. We therefore hope that others will investigate our claim that the plants and populations reported here are wildtypes.

Various circumstances make it highly likely that wildtype taros are naturally occurring in Myanmar. The first circumstance we wish to consider is the distribution of wildtype taros in Australia, where there is no known history of taro cultivation before European colonization.

In northeastern Queensland, in a wet tropical environment, wildtype taros occupy stable natural habitats at higher elevations (waterfalls), unstable natural habitats in the lowlands (soft stream banks), and artificial lowland habitats (roadside ditches for example) (Matthews 1991, 1997). In Myanmar, the range of habitats occupied (Table 1) is similar, but human activities in lowland areas (for agriculture, transport, water control, and settlement) have been more intensive, and locations with suitable habitats are more common. Wildtype taros are far more abundant in the modified landscapes of Myanmar than they are in the modified landscapes of northern Australia.

People in Myanmar have undoubtedly played a major role in the expansion of wildtype taro populations, but this is not necessarily a result of deliberate propaga-

Table 1 Habitats of wildtype taros in Myanmar

Apparently natural habitats		More-or-less artificial habitats (higher and lower elevations)
higher elevation (foothill, mountain)	lower elevation (lowland)	
spring source	soft stream bank	artificial island (floating garden) in natural lake
waterfall	lake edge	edge of water reservoir
rocky stream bank		bank or ditch alongside road or railway
soft stream bank		field canals
lake edge		ditch, pond, or damp bank in city or village

tion and transfer of wildtype taros, despite their food and fodder uses. Wildtype taros are fully capable of dispersal without human assistance, by seeds and vegetative parts.

The remarkable abundance of wildtype taros in many settlements in Myanmar appears to reflect the unintended creation of suitable habitats (often with highly fertile soil), and the value that people place on wildtype taros as a free source of food and fodder. Although taro is weedy where it invades gardens and urban areas and requires removal, it is generally regarded as a useful plant in other locations, and is not removed.

In the opinion of one of us (KWN), most people in Myanmar also regard wildtype taros as ornamental, or pleasing to the eye. Taro and lotus plants (often found in the same pond or lake) are recognized as signs of the rainy season, and artists are known to mark the season by showing a boy wearing a taro or lotus leaf on his head, and going to school in the rain.

Since people are mostly only harvesting wildtype taros, and not actively eliminating, propagating, moving or planting them, there is no obvious selection process. Although the relationship with people is symbiotic, wildtype taros also thrive outside settlements, in natural and disturbed habitats. Wherever people harvest the leaves of wildtype taros frequently, flowering is probably reduced but not eliminated. As a result, there may be continuous gene flow—through the dispersal of vegetative parts, pollen, fruit, and seeds—between wildtype taro populations within and beyond settled areas. With these considerations in mind, and with the evidence of long-term survival in one area of Yangon city, we suspect that most wildtype taro populations in lower Myanmar have retained their integrity as natural wildtypes, are resilient to harvesting, and are being sustainably harvested. With the possible exception of the geographically isolated population at Mt Popa, the circumstances described here conform well to what Cunningham (2001: 148–149) would regard as a medium to high opportunity for sustainable harvest of a wild plant resource.

Table 2 Summary of food and fodder uses of wildtype taros (*Colocasia esculenta*) in Myanmar

use	method	corm	stolon	young rolled leaf	mature (expanded) leaf		inflorescence		fruit
					petiole	blade	peduncle	spathe & spadix	
food	boiled[1]	-	yes	-	yes	yes	-	-	-
	baked	-	-	-	-	yes			
	salted	-	-	-	yes	-	yes	-	-
	sour soup	-	-	yes	yes	-	yes	yes	-
	curry	-	yes	-	-	-	yes	yes	-
	mashed	-	-	-	-	yes	-	-	-
	dried	-	-	-	yes	yes	-	-	-
	not specified	no	no, yes[2]	-	-	-	-	-	-
fodder	gruel	-	-	-	yes	yes	-	-	-
	not specified	no	-	-	-	-	-	-	-

yes = use mentioned
- = use not mentioned
no = use denied during one or more interviews
[1] = export product; local consumption not recorded
[2] = both responses are noted in our text
[3] = boiling in plain water; this is often the first step in other cooking methods

6.2 Providence

Matthews (1996) suggested that the first human use of taro was not necessarily as a starchy root crop, the dominant use today. It could have been used for any of many possible purposes initially, and for different purposes in different areas within its natural distribution range. How taro subsequently developed as a cultivated food plant must have varied widely in different natural and social environments.

The present survey shows, for the first time, that wildtype taros in one area (Myanmar) can be used in a variety of ways as both a food and fodder (Table 2). The presence and diversity of wildtype taros is providential because people generally do not make special or deliberate efforts to control or increase production of the plants, or select better forms. Wildtype taros are generally viewed as a natural resource, free for harvest by anyone. Presumably, this freedom does not extend without limit beyond the people in each local community.

Although we cannot provide any figures on consumption by animals and by people, it appears from many interviews that wildtype taros are currently much more important as fodder than as food. Since wildtype taros are abundant over very long distances (see travel route, Figure 2), and pig husbandry is common, taro may

be one of the most useful fodder plants in Myanmar, at present. By feeding wildtype taro to pigs, along with low-grade rice, low-grade human foods are converted into high-grade fat and meat. To compare the value of wildtype taro with other sources of green fodder, more information is needed concerning the nutritional values, availability, and usage of wildtype taros and other kinds of fodder.

The relative importance of wildtype taros as fodder or food is likely to have varied over time, and in different places. Food uses may have been more important than they are now during periods of famine, during incipient or early agricultural periods when fewer cultivated and domesticated plant species were available, and before the modern introduction of many new crops, including South American root crops such as cassava, potato, and sweetpotato.

The present abundance and usefulness of living wildtype taros does not mean that these plants are the progenitors of cultivated and domesticated taros in Myanmar. Progenitors are by definition plants that lived in the past. Genetic studies are needed to link the genealogies of living cultivars, living wildtypes, and hypothetical ancestors. Further field surveys and detailed morphological comparisons are also needed to define the ecological and geographical boundaries of wildtype taro populations.

Taro is a heterogeneous species that appears to have undergone domestication in more than one area of Asia and the Pacific. No single model of domestication is likely to explain the history of taro, and its cultivation in many tropical and temperate areas of the world. The present observations in Myanmar, although limited, raise the possibility that using wildtypes as fodder was involved in the domestication of both taro and pig. If so, there may also have been elements of providence in the synergies created when people, plants and animals began to develop closer relationships with each other.

One possible new synergy would have been an increased concentration of nutrients from human and animal wastes, in water and soil, in the vicinity of wildtype taro populations. A positive feedback cycle may have led to greater productivity in plant, animal and human populations. Complex communities of many plant and animal species may have been involved at every point in time, and positive feedback cycles could have been initiated before actual cultivation and domestication of the plants and animals. If the domestication of nutrient cycles, and human dependence on domesticated nutrient cycles, can be accepted as defining characteristics for agriculture, then the possibility arises that agriculture began before the selection and genetic modification of wildtype plants and animals.

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