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## **‘Certainly the Most Technically Complex Pondfield Irrigation Within Melanesia’: Wet Taro Field Systems of New Caledonia**

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New Caledonia, the southern-most archipelago of Island Melanesia, is known for its complex types of taro terracing, considered as the most elaborate of the Western Pacific. The present paper proposes a general synthesis on this unique expression of wet taro production, by highlighting first the very preliminary knowledge that we have on the chronology of its development, apparently mainly linked to the rise of the Traditional Kanak Cultural Complex in the second millennium AD. The central part of the paper describes, from archaeological data as well as ethnographic accounts and present-day practices, the different types of wet taro field systems on the ‘Grande Terre’, the main island of the archipelago. Although taro was planted in marshy/lowland terrains near the seashore and in the large plains, most of the visible remains are located on the hillsides, where extensive terracing and water channeling resulted in the construction of large intensified pondfield sites. The link between these large horticultural complexes and the unique geology of Grande Terre is highlighted in the analysis, helping to explain the massive development of pondfields in New Caledonia.

### **1. INTRODUCTION**

Since their very first encounter in 1774, Europeans have been impressed by the large and complex field systems used to plant the wet taro, *Colocasia esculenta*, in New Caledonia (Fig. 1)—and by the skills and hard work with which these systems were built by the Kanaks, indigenous inhabitants of the archipelago. Describing his visit to the region of Balade on the north-east coast of Grande Terre, the main continental island of the Archipelago, Captain J. Cook wrote in September, 1774, that:

‘the Country (...) was finely Cultivated and laid out in Plantations of Sugar [plantains], yams and other roots and Watered by little rills, conducted by art from the main stream whose Source was in the hills. (...) (T)heir plantations in the Planes (...) were laid out with great judgement and cultivated with much labour. (...) Tarro Plantations were prettily Watered by little rills, continually supplied from the main Channel where the Water was conducted by art from the River at the foot of the mountains. They have two methods in Planting and raising these Roots, some are planted in square or oblong Plantations which lay perfectly horizontal and sunk below the common level of adjacent lands, so that they can let in as much water upon them as necessary. (...) (O)thers are planted in ridges, (...) on the middle or top of the ridge is a narrow gutter along

which is conveyed a small stream of Water which Waters the roots planted on each side, the plantations are so judiciously laid out that the same stream will Water several. These ridges are some times the divisions to the horizontal plantations, where this method is used not an Inch of ground is lost' (Beaglehole 1961: 531, 534, 538).

More than two hundred years later, each new visitor to the island continues to be struck by the vision of massive field systems composed of terraced taro pond-fields, today mostly abandoned but still visible on hillsides in numerous regions of Grande Terre. As repeatedly emphasized since 150 years ago, these complex horticultural systems have probably been the aspect of Kanak traditional economy 'most affected (...) by the (French) colonizing process' (Barrau 1956: 80). Barrau (*ibid*) regarded them as 'certainly the most technically complex pondfield irrigation within Melanesia' (Kirch and Lepofsky 1993). Aside from the terraces visible on roadsides, archaeological surveyors rediscover, year after year, former taro pond-fields hidden under forest cover, sometimes at locations far from any present-day habitations. In the present paper, I will try to summarize the characteristics of this Oceanic planting tradition, which reached in New Caledonia an unparalleled complexity of terraced fields on steep

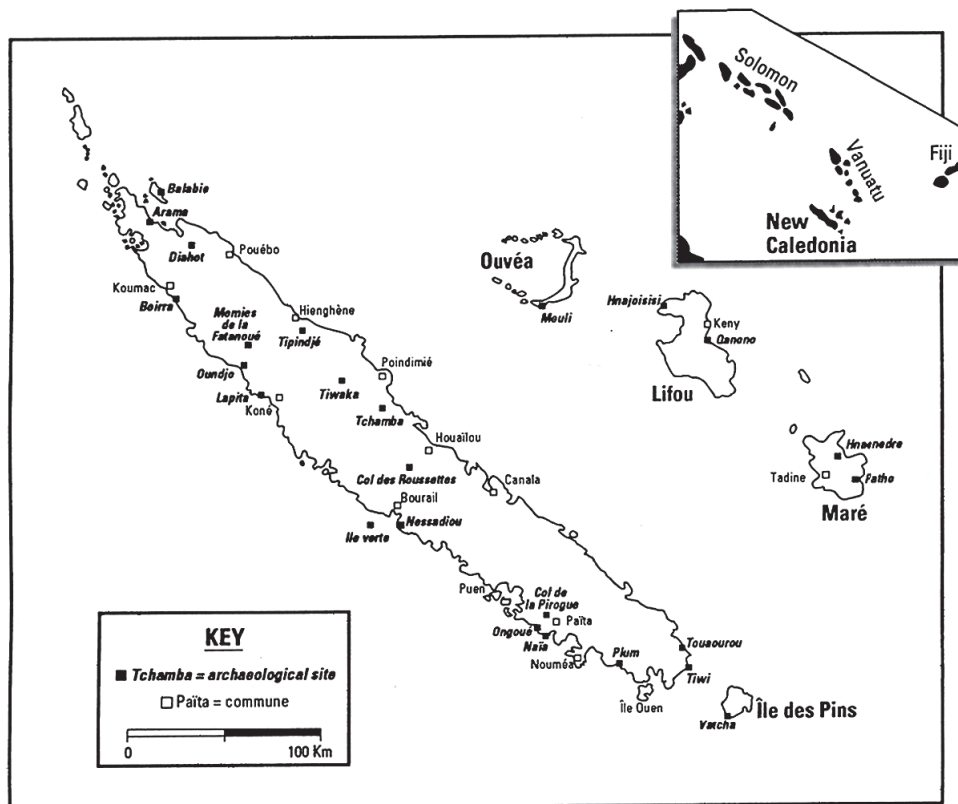


Figure 1 Location of New Caledonia within Island Melanesia

slopes (Kirch and Leposfky 1993: 191). Relying on first-hand descriptions of 19<sup>th</sup> century Kanak taro plantations by Europeans and ethno-botanical studies, as well as recent archaeological surveys and excavations, I will try to propose a general typology of different taro pond-field systems on Grande Terre. Using a few direct <sup>14</sup>C dates as well as indirect chronological data, the Kanak tradition will be put in a general historical frame, hoping to prompt renewed studies dedicated specifically to this topic.

## 2. GENERAL BACKGROUND

*Colocasia esculenta* (taro) is widespread across Africa, Eurasia, the Pacific and (more recently) the Americas (Matthews 2006). The plant needs wet soil and warm temperatures to grow properly. Although probably first planted in naturally wet marshes or on the wet banks of rivers and streams, most Pacific island societies have over time developed complex field techniques to plant the crop (Brookfield 1972). The basis of all intensified taro cultivation is irrigation, be it through the diversion of flowing water from a source or a creek/stream, or by converting a natural wet area, or by reaching a buried water lens (Spriggs 1982). The last two cases are the only ones possible in small flat islands like the uplifted coral islands of the Loyalties, which form the eastern part of the archipelago. This is for example the case in Ouvéa, where the inhabitants have dug into sand dunes to reach the water lens, sometimes several meters below, forming successive rows of planting pits (Lekine tribe) or large-scale wet field systems (Fayaoué tribe). After creating compost, they plant their taro in the artificially swampy ground (Sand 1995: 180–181). In a related geological context, small sunken swamps naturally present at the foot of limestone cliffs on Isle of Pines were used to plant *Alocasia macrorrhizos*, a former crop that now persists in such locations in a fallow state (Lagarde *et al.* 2009).

On the Grande Terre of the archipelago, irrigated field systems were developed to their maximal diversity, extent, and complexity for the cultivation of taro. In the vast majority of cases, this was done through the diversion of naturally flowing water from rivers or streams, in order to irrigate networks of terraces on hillsides and complex sets of banks and ditches in flat areas. The most impressive achievements still visible in the landscape are huge successions of abandoned taro terraces covering sometimes several hundreds of hectares of hill- or mountain-side (Fig. 2). The extent of these terrace systems is unparalleled anywhere in the Pacific, and their full extent has only recently begun to be realized through archaeological surveys. Already in the late 19<sup>th</sup> century, the amateur archaeologist G. Glaumont emphasized that the most logical explanation for the development of such huge terrace systems on hillsides must have been the near-total prior use of all available flat plains for cultivation, necessitating expansion into less favorable areas (Glaumont 1897/1953). The collective work needed to achieve this, and the complex social structure involved in expanding and maintaining these systems, were integral to a process of massive intensification during development of the ‘Traditional Kanak Cultural Complex’ in the second millennium AD (Sand *et al.* 2003). In order to put the main types of wet taro field system into historical perspective, I will present the relevant chronological data next.



**Figure 2** Example of extensive taro terracing on the hills of Col des Roussettes (Central Grande Terre)

### 3. CHRONOLOGY

No remains of taro have been identified to date in archaeological excavations in New Caledonia. But the discovery of taro starch in different Lapita sites of the Western Pacific (e.g., Crowther 2005, 2009) is consistent with the introduction of cultivated taro by the first Austronesian settlers in the region, about 3000 years ago, as suggested by Green (2003). Apart from local scholars like J. Barrau (1956: 73) or D. Bourret (1981), few ethnobotanists in their studies of taro in New Caledonia, have really attempted to identify cultivars that may be descended from the earliest introductions of species such as *Colocasia esculenta* and *Amorphophallus campanulatus* (Rox.). Linguistic reconstructions highlight a number of terms in Proto-Oceanic that are linked to wet taro planting techniques. The first Lapita discoverers of Remote Oceania presumably planted different varieties of taro in wet soil (Osmond 1998: 116), some probably creating simple pits near streams, but ‘no reconstructions have been possible for such concepts as ditch or water channel or irrigated garden’ (Osmond 1998: 139) for this early phase of chronology in Remote Oceania.

To begin developing more intensive production techniques, for example fields supplied by long water channels and artificial terraces arranged in a vertical series, two conditions were needed, as already noted by Yen (1973): a need linked to demographic pressure, and a social dynamic that allowed organization of the intensification process (see Spriggs 1990). To

these two main conditions, archaeology today is able to add two further suggestions. The first is that landscape degradation after first human settlement is likely to necessitate progressive development of new planting traditions, which then helps to release the pressure of simple slash and burn techniques on the fragile ecology and environment of islands (Barrau 1961: 18). The second, for New Caledonia at least, is that climatic fluctuation may influence social and technological change. Recent reconstructions of climate change for the past 1500 years or so in the Western Pacific have shown a succession of wet and dry periods (*cf.* Dotte 2010, for New Caledonia). These fluctuations may have prompted Pacific islanders to develop complex but more secure cultivation systems to counterbalance weather uncertainty. Although still fairly crude and not sufficiently local or island-based, climate reconstructions have highlighted a series of dry periods during the late first millennium AD, and the few centuries after, before the development of wetter conditions (Dotte *et al.* 2010: 221–225). The dry weather episodes may have fostered the development of controlled wet planting, to counterbalance poor conditions for dryland crops. Climate needs to be taken into account for historical reconstruction, but climate fluctuation alone cannot be identified as the main factor responsible for intensification (*contra* Nunn 2000)—that would be a deterministic and far too simple analysis of cultural dynamics.

Ethnographer M. Leenhardt recorded in the early 20th century in Houailou (central East coast of Grande Terre) that it was ‘ancestor-strangers’, the *Panyamanya*, who taught Kanaks how to build taro terraces (Leenhardt 1930: 112). The apparent uniformity of the taro terracing that is widespread on Grande Terre is probably mainly due to the rigid physical constraints on the technique. This also leads it to look, at first sight, like any Oceanic taro or even Asian rice terrace.

On linguistic grounds, Kirch and Lepofsky have emphasized the ‘reinvention’ of the terracing techniques in the Pacific (1993; see also Osmond 1998). This must concern only the Western Pacific, as dates at a few sites show the appearance of taro pond-field terraces (Di Piazza 1990; Sand 1993) before the settlement of Central Polynesia (Wilmschurst *et al.* 2010). Early development of the tradition in one specific archipelago within the region, or more locally in one area of Grande Terre before its spread to the entire island, cannot be ruled out on present evidence.

The dating of archaeological cultivation sites by  $^{14}\text{C}$  analysis is inherently difficult because sediments in a cultivation area are generally reworked every planting season, from top to bottom. It is never easy to know what event is actually dated, since the charcoal recovered for dating might be derived from the original vegetation present at first creation of the site (in the present case, a terrace), or from the clearing and burning of fallow ground centuries later, or from the last use of the site before abandonment. In New Caledonia, the very limited amount of excavation of former taro fields allows only a first general chronology to be proposed. The few  $^{14}\text{C}$  dates presented here were all obtained from charcoal of unidentified species origin (Table 1). Two dates from widely separated sites indicate the existence of pondfield terracing already in the second half of the first millennium AD. The oldest date so far came from a buried pondfield layer in the upper Pamale valley in the centre of Grande Terre. This layer was buried under recent alluvium, and charcoal from the layer gave an AMS date of 1530 $\pm$ 40 BP (Beta-227957), calibrated at two sigma to AD 420–610. A second



**Table 1** Radiocarbon dates ( $^{14}\text{C}$ ) for taro terrace layers in New Caledonia

Location	Site	Context	Sample code	CRA	Cal age (AD)
Upper Pamale Valley		buried pondfield	Beta-227957	1530 $\pm$ 40	420–610 (2 $\sigma$ )
Col de la Pirogue	WPT069	interface of two cultivation layers	Beta-61956	1210 $\pm$ 70	670–970 (2 $\sigma$ )
Col de la Pirogue	WPT069	road cutting through terrace	Beta-136940	560 $\pm$ 40	1305–1430 (2 $\sigma$ )
St Laurent	WPT059	palisade posthole	Beta-59963	300 $\pm$ 20	1450–1675 (1 $\sigma$ )
St Laurent	WPT059	upper layer	Beta-59962	130 $\pm$ 90	1680–1765/ 1800–1890 (1 $\sigma$ )
St Laurent	WPT053	buried water channel	Beta-64646	250 $\pm$ 70	1520–1680/ 1760–1805 (1 $\sigma$ )

sample came from the interface of two superimposed cultivation layers in a pondfield terrace at Col de la Pirogue (site WPT069) on the Southwest coast of Grande Terre. This gave a date of 1210 $\pm$ 70 BP (Beta-61956), calibrated at two sigma to AD 670–970. The sample position indicates that it may mark the last stage of use of the earlier cultivation layer. The terrace concerned lies in a particularly attractive position within the field system, in a nearly flat zone with good soil, at the foot of the hill and near to the water source (a stream). This area may have been where construction of the terraces began. From the observations, it can be inferred that the first phase of building of the terrace started not long before the date obtained (if the terrace was among the earliest in the sequence), pushing the beginning of construction to perhaps the middle of the first millennium AD, or soon after, in the Païta region (Sand 1994: 60).

The few other dates obtained so far cluster in the second millennium AD. Charcoal was obtained from an abandoned pondfield terrace exposed in road cutting at the Col de la Pirogue site complex, and was dated by AMS to 560 $\pm$ 40 BP (Beta-136940), calibrated at two sigma to AD 1305–1430. Direct dating of a more recent terrace was possible after excavation of the uppermost terrace in a field system at St Laurent (site WPT059), also on the Southwest Coast, at the foot of Col de la Pirogue. The excavation uncovered an alignment of several postholes at the foot of the terrace, interpreted as remains of a palisade built to hold soft planting soil brought from another location, directly placed on the sterile substratum. Charcoal from the base of one posthole gave a date of 300 $\pm$ 120 BP (Beta-59963), and charcoal from the upper layer of the same site gave a date of 130 $\pm$ 90 BP (Beta-59962), calibrated to the last centuries before contact. On the nearby site WPT053, the bottom layer of a profile, interpreted as a buried water channel, was dated to 250 $\pm$ 70 BP (Beta-64646). These results demonstrate that the tradition of terrace building continued during the whole second millennium AD, people expanding their field systems to even more remote and difficult locations in the less fertile or completely infertile upper-hills, where the entire volume of planting soil needed to be introduced from further downhill.

Aside from direct  $^{14}\text{C}$  dating, a general indirect dating of the development of taro terracing can be made through a wider cultural chronology. As earlier noted, the intensification of landscape use must have been related to some form of need, associated with demographic

expansion and socio-cultural dynamics. Massive expansion of site numbers is observed from the end of the first millennium AD and over the entire second millennium AD in New Caledonia, and characterizes what has been defined as the period of the ‘Traditional Kanak Cultural Complex’ (Sand *et al.* 2003). Taro field systems were clearly integrated with other specifically Kanak archaeological structures (clusters of raised house-mounds forming hamlets, dryland raised plantations etc.). This, and the presence of wetland taro systems on seashore locations that were not geologically formed before the end of the first millennium AD (Sand *et al.* 2002), indicate that the main phase of intensified taro production was during the last thousand or so years before first European contact.

#### 4. THE DIFFERENT TYPES OF WET TARO FIELD SYSTEM ON GRANDE TERRE

Although understanding of the chronology of indigenous agricultural development is still in its infancy, archaeological surveys over the past two decades have started to clarify the main types of field system that were constructed by Kanak farmers for wet crops (mainly taro). The following outline begins at the seashore then moves inland, to coastal wetlands and plains, then hills and upper mountains.

##### 4.1 Seashore Structures in Swampy Terrain

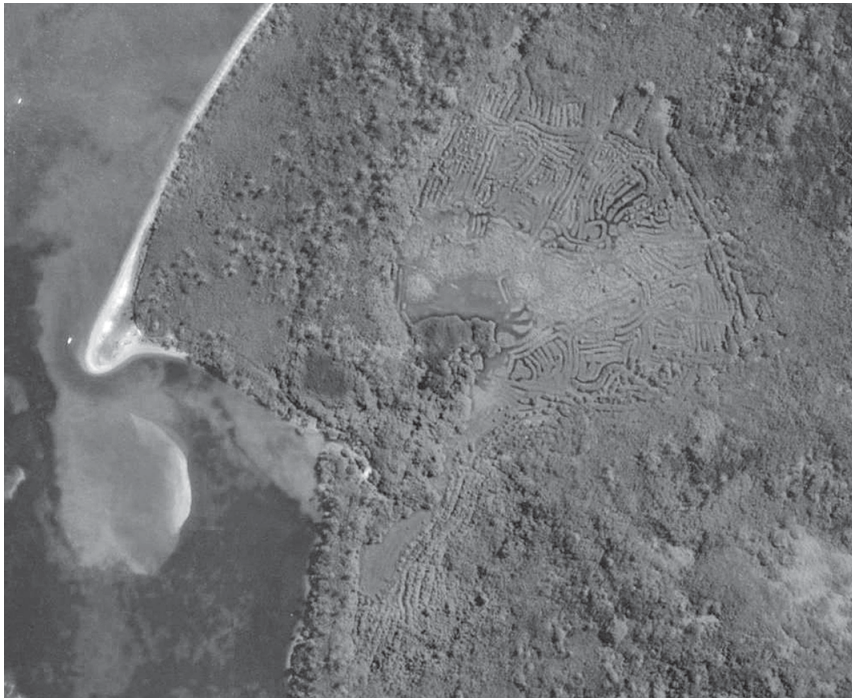
As in other Pacific archipelagos (*cf.* Spriggs 1984), wet taro plantations on Grande Terre extended down to the seashore, on sandy/swampy terrain and in mangrove areas. At Balade, Forster saw in 1774 that:

‘some of the eddoes [Taros] were actually set under water. (...) (W)e passed a plantation, where the natives, and particularly the women, were at work to clear, and dig up a piece of swampy ground. (...) The narrow plain (...) is full of swamps on the sea-side, covered with mangroves; and this part is with much trouble drained by ditches, and dug till it is made fit for purpose of agriculture’ (Forster 1996: 571, 587, 588; translation from the French).

The principle is to drain marshy flat areas influenced by tides, in order to improve the flow of fresh water from inland sources. Because of its location, this type of planting system is fragile and has often vanished over the past 200 years of abandonment and colonial landscape modification. Just one example has been tentatively recognized in archaeological excavations, at the seashore site of Boirra in Koumac (site NKM001), where D. Frimigacci discovered a series of infilled ditches lined with cut beach-rock slabs (Frimigacci 1978). The stratigraphic profiles, excavation photos, and discovery of a possible network of ditches all around the Boirra site (Sand 1989), may indicate an artificial set of wet-land cultivation fields, today buried under the sand (Frimigacci, pers. com. 1988).

One dramatic example of the former complexity of some of these near-shore wetland fields can be seen on the swampy coast margin of the small island of Yandé, off the northern point of Grande Terre. The 5.7 km long by 4 km wide island is mostly hilly and today infertile. Planting efforts appear to have been mainly concentrated on the marshy coastal flats, which are the only locations with fertile soil. At one such location, in an area that is now





**Figure 3** The dense horticultural layout of banks and ditches on the west coastal flat of Yandé Island (off northern Grande Terre)

partly covered by mangroves, we can identify a complex pattern of ditches that surround numerous raised beds for wet crop planting. Some structures appear to start at the foot of the hills, and may have also allowed the development of dry-land fields away from marshy soils. The total transformed surface that can be identified today exceeds 20 hectares, including habitation areas (Fig. 3). This site shows full intensification of land use along the entire seashore area, and indicates a major cultural shift on this small and remote island in the past.

More quadrangular field systems, relying on the same hydrological principles as in the preceding case, have been recorded in Yaté on the south-east coast of Grande Terre (Sand and Ouetcho 1993).

#### 4.2 Flat, Lowland Cultivation Sites

The flood-plains of Grande Terre have a variety of characteristics depending on their location. Broadly speaking, they can be divided in two main groups: the first is found on large plains on the open and wide West Coast; the second is found in more narrow river-valleys opening towards the East Coast. G. Glaumont gave a vivid description of former flat, lowland cultivations:

‘Taros are (...) planted in flat terrain. Here, in a less difficult environment (than on the hills), with less maintenance work, will we see the native planter give way to his vagabond and artistic

imagination. We know the always well-structured concentric or rectilinear motifs that the natives carve on their house posts or on bamboo. Well, for taro plantations in flat terrain, they appear to have been inspired by these motifs. When a water source that they have used for their mountain pondfields arrives in the plain, they use it to fertilize and water their fields in flat terrain. But the natives will not simply drown it and transform it into a large pond where taros will grow. Like in the mountain, he wants to see all the crops that make up his food grouped together and he wants to be able to wander around in his plantations. In order to achieve this, he digs in flat terrain a looping channel that forms a design like the outline of a propeller. This creates a ditch full of water where the taro grows and a raised platform planted with sugarcane, bananas etc. ... The width of the ditch doesn't exceed one or two meters. The native can get over it easily to wander around among his plantations or to harvest whenever he needs to.

The motifs created by these planting grounds are infinite. I will mention here only a second example that I have seen in Ile Ouen and in the north of the colony, along the Diahot river. The ditch is rectilinear. The water follows an inward direction radiating in staggered rows inside the loop of the lateral branches, which interpenetrate each other in a labyrinthine design. The water finishes its course after having watered parallel series of planting beds. Sometimes, after this, the water gets used to water another isolated part of the field system. Another even more complex motif can exist, where the water flows in and out after having travelled through a huge circuit. I must add that the water must be nearly stagnating or move slowly.

The native has here evergreen planting grounds. The huts being raised nearby and surrounded by coconut and banana trees, he has in immediate access all the plants that make up his daily food' (Glaumont 1897/1953: 33–34; translation from the French).

Most of the West Coast plains have been transformed by extensive ranching over the last 150 years and little remains of the former large-scale wet taro fields in this part of the Island, although their existence all along the coast is indicated by early European description. During the first series of military raids in the Païta region just outside the colonial Capital of Nouméa in 1856–1857, French soldiers got lost for nearly a whole day in the wet field systems of the plain. Some estuaries of the West Coast (Poya, Koné) still preserve observable remains of former extensive flat, lowland systems, which would have been present in numerous locations in the past, with a possible massive case associated with the only substantial river of the Island, the Diahot. The flood-plain of the Koumac stream in the northern part of Grande Terre is one well-preserved example, with banks and ditches starting about three kilometres from the coast and ending at the back of the beachfront (Guillaud and Forestier 1996), thus covering an area of over 400 hectares.

Better-preserved sets of banks and ditches are known in a number of plains of the East Coast. The best studied case to date is in the lower Tiwaka river plain, where over 40 hectares on the left bank of the river was drained, creating field-systems that probably supported simultaneous planting of dryland crops on raised mounds and wetland crops (mainly taro) in the maze of ditches surrounding them. Thirty-five hectares of the area is still well preserved (Fig. 4), and archaeological study has shown the cumulative digging and maintenance of more than



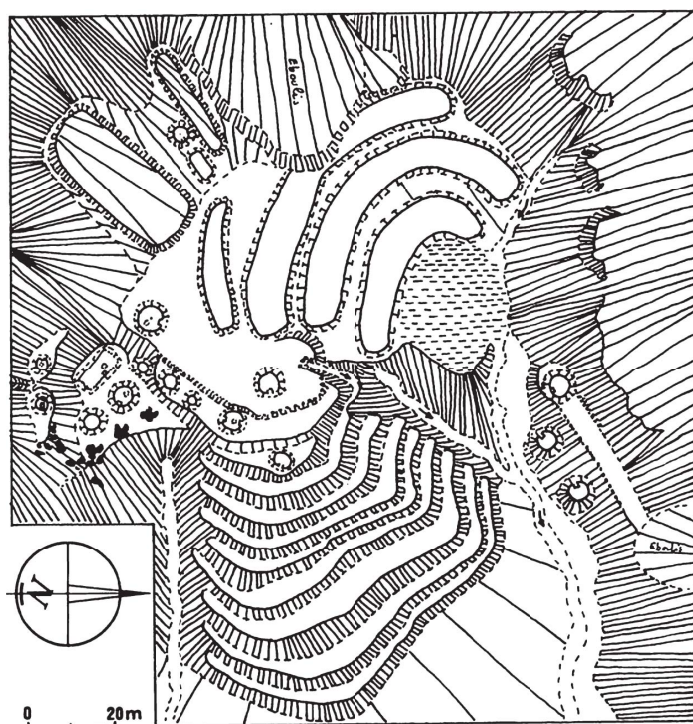
**Figure 4** Air view of the Tiwaka river plain, highlighting the succession of ditches dug for water circulation and the different areas of habitation

25 km of ditches, surrounding habitation sites set alongside dry-land raised fields (Sand and Ouetcho 1993; Dotte 2010).

#### 4.3 Small-Scale Terracing of the Inner Valleys

The least visible wet taro planting structures of Grande Terre are small-scale and located inland, and are now covered by forest or bush. The total number and area of sites are difficult to assess, but archaeological surveys indicate a profusion of small-scale terrace systems that cover just a couple of tens of hectares each, or less.

The limited amount of flat land in the inner valleys appears to have been mainly reserved for dryland planting of yams. Most of the wetland crops appear to have been planted on terraces in these areas. Less often preserved are large ponds (large by New Caledonian standards). These were constructed on river-flats, reached sometimes 800 square meters in surface area, and are only observed today in remote regions where colonial cattle raising has not been important. The ponds are often the downhill part of larger terrace-systems constructed on steeper terrain, with the terraces appearing far more numerous. The extent of the hill-terraces varies from site to site. A dozen small-scale pondfields have been recorded along some banks in the upper Koumac stream (Guillaud and Forestier 1996: Fig. 48). Some sites may be composed of only a few terraces, because they are water-fed by a simple spring and not a creek. This is the case of the site of Kadèn (ETO045) in the central ridge of Grande Terre, where archaeological mapping has shown a close proximity between a former Kanak habitation site, raised dryland fields, and a couple of taro pondfield terraces (Fig. 5).



**Figure 5** Map of the Kadèn site (ETO045) in the central part of Grande Terre (Bopope), combining housing, long dryland cultivation mounds and wet taro terraces watered by a source

In other cases, it is the naturally small size of a valley that limits the possible expansion of terraces. In such cases, the builders often pushed construction techniques to their limit, some terraces being built on very steep terrain. In the Hienghène region, in the northeast part of Grande Terre, the overall steep nature of the environment led to a tradition of stone-faced terraces. At their extreme, planting platforms less than one meter wide were retained by dry-stone walls more than three meters high (Fig. 6) (Sand *et al.* 2005). The dry-stone wall technique appears to have also been applied to the banks of most rivers and streams in this part of the Island. The vertical succession of terraces, in every small and steep valley of Hienghène, is now almost entirely under forest. The terrace systems of the inner valleys must have created a fascinating landscape at the time of their use.

#### 4.4 Extensive Terraced Pondfield Sites

The largest and most cited type of Kanak taro pondfield system in the archaeological literature is seen at a number of very extensive sites. As usual for Melanesian horticultural sites, detailed studies of these sites are lacking, with most authors relying on general observations. These very extensive sites, covering over 200 hectares each, have been found in most regions of Grande Terre. A few huge examples must be highlighted, in Pouébo, Houaïlou, Canala, Thio, Bourail and Païta especially. The largest of all appears to be located around the Col des





**Figure 6** Example of high stone-faced walls for taro terracing in the upper part of the Werap valley (Hienghène)

Roussettes, at the back of the Bourail region in the central part of the Island, facing the West coast. The visible remains of terraces extend here over an area of more than 3000 hectares (Roux 1990: Fig. 8) without any major break. Some hillsides display a continuous sequence of more than 80 terrace steps (Fig. 7). No survey or mapping of this huge and unique horticultural complex has been done to date, preventing the definition of its spatial limits. Preliminary observations indicate the presence of further terrace systems to the north-west towards Daoui stream, and to the south-east towards Téné stream. The best description of a part of the complex was certainly made by G. Glaumont over 100 years ago:

‘One of the most remarkable taro pondfields that I have witnessed is located in Téné. Téné is located about 17 km from Bourail, at the foot of the central mountain ridge. It is an immense basin that the white settlers have given the distinctive name of ‘the Devils’ Hole’. The colonial station is managed by a settler called Drouin. We went to the site together and counted the presently empty sites of over twenty villages and a thousand house-mounds or fire places. Immense taro pondfields criss-cross the mountains all around the valleys. We can evaluate its minimum extent to at least 100 km, taro pondfields starting at the top of the mountains and criss-crossing all the contours of the hills to their bottom.

To give an idea of the aspect of an old taro pondfield, today in dry state and in fallow, to those who have never seen any, this is I believe a present monument to which it can be compared. With the Téné valley forming the back part of the basin, and the mountains surrounding it being the sides, the onlooker placed in the centre would enjoy the same kind of view experienced from the centre of a Roman circus, the Colosseum for example, and would look on all sides to the bleachers rising up to the summit of the circus (...).

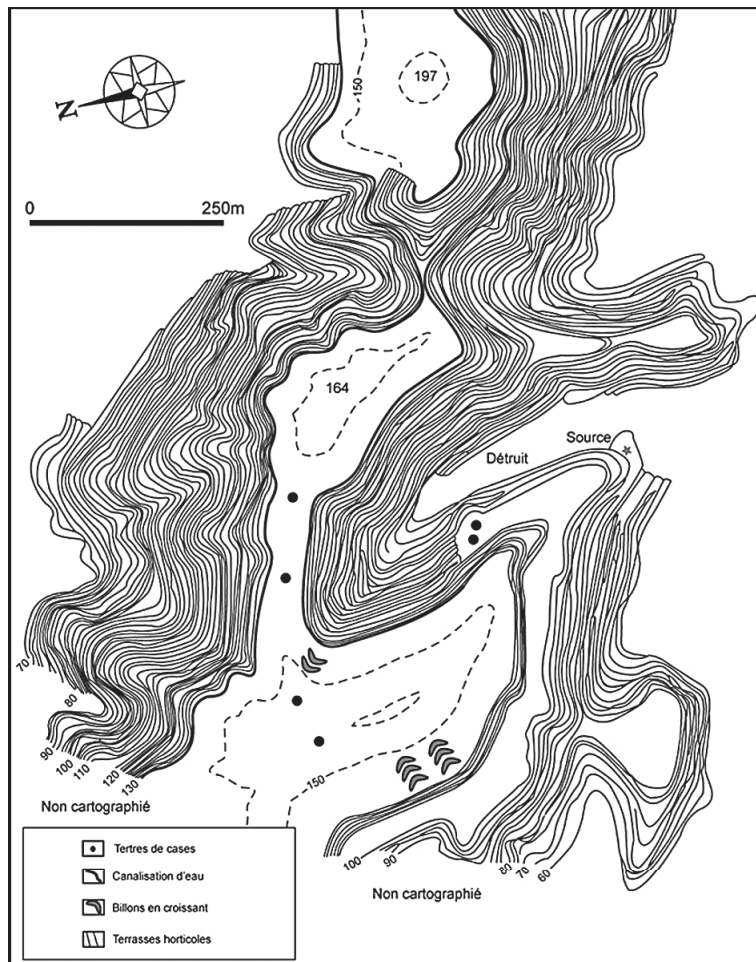


**Figure 7** Partial view of the extent of terracing around the upper part of Col des Roussettes (Bourail)

We must add to this that the water channels contour the mountain by following its windings, and continue towards a number of other hills. The native was able, with the same water course, to water three or four hills and even more. (...) If we imagine all these ditches, today dry and half collapsed, inundated, if we mentally plant them with taros topped by large green leaves, and if we recreate on the talus slopes, fields of sugarcane, bananas and all the grasses that must have been growing on this soil always watered and heated by the scorching sun, we will get the really enchanting image that the valley of Téné must have had in the past’ (Glaumont 1897/1953: 33; translation from the French).

A survey of similar field systems at Col de la Pirogue (Païta, Southwest coast) has highlighted the complexity of terrace extension and water circulation that is revealed when this kind of site is studied in detail. Tens of thousands of terraces still cover slopes for 30 km along the foot of the mountains of Païta, forming a succession of large integrated pondfields. The currently known area of the terrace complex in Païta is over 1200 hectares, and new parts continue to be found in hidden forested locations on private property (Sand 1994). Aside from the main complex of Col de la Pirogue, no less than 22 different taro terrace complexes have been recorded. For the Col de la Pirogue area alone, nearly 30 main water channels have been surveyed, the highest starting at about 450 m altitude, the lowest built at the very bottom





**Figure 8** Map of part of the pondfield wet taro system of Mont Koghi in Dumbea, showing the general layout of terraces that can still be identified today, after over 100 years of abandonment

of the hills supporting the terraces, pointing to the former existence of now-destroyed pond-fields in the flat lowlands. This complex covers an area of about 500 hectares of what is basically one continuous set of terraced field systems. At the nearby complex of Bangou, which stretches for 0.5 km along the foot of the mountain, six main water channels have been identified, all stemming from one large stream.

Another example, at the site of Mont Koghi in Dumbéa, was partly mapped in 1993 after fire burned the bush covering the terraces. The 50 hectare area surveyed was watered by at least six different sets of water channels (Fig. 8). The highest of these, irrigating the uppermost terraces, had to be carved in rocky hill soil and is over 2 km long, from stream source to the pond-fields. The lower water channels are shorter, marking the logical trend of upward development of the terrace system over time, into soil of decreasing quality. The summit

areas could not be irrigated, and were used for habitation and dryland planting. They still display the remains of crescent-shaped yam fields and raised house mounds.

## 5. GRANDE TERRE’S GEOLOGY IN THE DEVELOPMENT OF PONDFIELD TERRACING AND QUESTIONS OF PRE-CONTACT KANAK DEMOGRAPHY

This overview of traditional wet taro cultivation systems on the Grande Terre of New Caledonia has highlighted the diversity and complexity of these cultivation systems developed by the Kanaks, mainly over the last 1000 years of landscape intensification before first European contact. Archaeological studies on this topic are still in their infancy and need to be expanded to get a better understanding of the chronology, typology, and diversity among regions and sites. Unfortunately, any future study will probably miss one of the main aspects of former Kanak taro planting, related to the diversity of localized varieties of *Colocasia esculenta*. As already noted by J. Barrau over 60 years ago, ‘when looking at the diversity of tubers, the natives agree that a great number of them have disappeared with the decay of the pondfield planting of taros, which followed French colonization and the setting of extensive cattle raising on the Island’ (Barrau 1956: 75). Genetic studies of crop varieties that can still be recovered on the island, will certainly give just a glimpse on the crop diversity that the Melanesian planters built up over a nearly 3000 year period of plant introduction, selection, and manipulation.

Many questions arise concerning the cultural and demographic dynamics that prompted increasing complexity in socio-political systems, increase in population, and intensification of landscape use. These questions and the use of past-climate fluctuation models to explain cultural changes, will certainly continue to be debated in the coming decades (Sand *et al.* 2008). Whatever the exact process of Kanak intensification during the second millennium AD, the unique development of complex and sophisticated wet taro pondfield systems on the Grande Terre of New Caledonia must also be intimately related to specific geological characteristics of the Island.

After its split from former Gondwanaland about 80 million years ago, and a long period of subduction, Grande Terre was partly covered during the upper Eocene (37 M) by part of the Oceanic crust, rich in metallic soils (Paris 1981). Progressive erosion of the uplifted crust led to the formation of a peridotite cover over about one third of the Island. The areas of peridotite have very acidic soils and were not used extensively by Pacific Islanders (but see Sand *et al.* 2012) before the start of mining during colonial times. The geological characteristics of this crust make it porous, water filtering easily into the acidic soil. When reaching the lower limit of the peridotite crust, the filtered water touches harder and less porous rocks of the geological substrate. Most of the water is forced along the upper part of the substrate and exits to the ground surface at the foot of the peridotite crust, forming innumerable springs and small streams. The spatial extent of the peridotite geological cover is such that this natural water flow is relatively unaffected by the dry season, as water storage inside the peridotite crust is massive. Sources continue to flow for months and months, even without new rain.

On an Island that, even without climate fluctuation, is regularly hit by cycles of dry weather lasting sometimes several years, the continuous flow from underground water sources



**Figure 9** Example of the link between peridotite mountains and extensive taro terracing in Bourail

must have been discovered by the first settlers occupying the foot of the peridotite mountains millennia ago. General observation of the positions of the largest taro pondfield systems on Grande Terre shows without question that many of them are located just under, or in the immediate vicinity of peridotite mountains (Fig. 9). This is the case especially for the entire southern half of the Island (Mont Dore, Dumbéa, Païta, Thio, Canala, Houaïlou, Bourail, Moindou), and also for a number of large sites in the northern half of Grande Terre (Poya, Pouembout, Koné, Koumac). Significantly, in places like Yaté (South-east coast), where the peridotite crust extends nearly to the upper margins of the plains, no terraced pondfields have been identified on the hillsides.

Of course this link between a specific geological formation and the development of large-scale terracing does not mean that no terraces were built in regions without peridotite. But in regions without the peridotite crust, the extent of each field system appears less important, possibly with different characteristics that still need to be properly identified. The unique sophistication of Kanak wet taro terracing was undoubtedly influenced by the unique geological environment of Grande Terre, planters taking advantage of a potentially infinite water source to develop complex, permanent yet fragile irrigated planting systems. Interestingly, the eternal water flow in Grande Terre's mountains is reflected in oral traditions, with stories speaking of coastal tribes starving because of a massive drought, then turning to taro planters

in the mountains to get food (Guiart 1957).

The massive extent of the taro pondfield terraces of Grande Terre is one of the most evident signs of a former large Kanak population size on the Island. The question of pre-contact Melanesian demography has been debated since over a century by Western scholars, with until fairly recently, a general consensus on low population densities (see Mc Arthur 1967). Challenging the orthodox view drawn mainly from anthropological and historical analysis, a few archaeological studies have started to demonstrate the evident underestimates of census collected well after the first contacts between Pacific islanders and Europeans. These studies rely on habitation sites (Best 1984) and intensified horticultural structures (Spriggs 2007) to support the demonstration of high population estimates in the Western Pacific in late prehistory, massively impacted by introduced diseases after contact (Kirch and Rallu 2007).

The case of New Caledonia on this topic is again revealing, as the archipelago has been seen as one of the areas of the Pacific where population shrink had been amongst the less severe (Rallu 1990). Over nearly two decades, local archaeologists have accumulated field data that show how much this long-held assumption of a low pre-contact Kanak population is incorrect (Sand 1995). A simple analysis of taro terraces production in the Païa region has shown for example that even with low yield, the population numbers in the narrow southwestern part of Grande Terre would have been nearly half of the historical orthodox estimate of about 40,000 Kanaks (Sand 2000: 66). Even estimates of about 100,000 people made on a preliminary study of visible horticultural field systems (Roux 1990) appear today too low, although archaeologists haven’t reached the stage to be able to securely propose a demonstrable alternative figure, too many cultural processes still needing better understanding (Sand *et al.* 2007). Even without being ready to publish numbers, it remains nevertheless that the impressive extent and complexity of Grande Terre former taro systems are testimony of a massive intensification process at work over the millennium before first contact. The low figure of under 20,000 Kanaks on the main island at the beginning of the 20<sup>th</sup> century (Rallu 1990: 277) was the endpoint of what must have been a catastrophic population collapse, probably not very different in scale to better known examples like Aneityum in Vanuatu (Spriggs 2007) or the Marquesas Islands (Rallu 2007: 30–31). With the former indigenous population severely reduced and most of the former Kanak lands taken by colonial settlers, the tradition of large-scale taro planting nearly died out in the 20<sup>th</sup> century, shrinking to relic plantations of only a few terraces in some tribes of the remote valleys today.

## 6. CONCLUSION

Although they are among the best known pondfield systems studied to date in Melanesia and the Western Pacific, the Kanak taro pondfields of New Caledonia’s Grande Terre still hold many secrets. Archaeological data suggest that the large majority of the terraces and coastal ditches still visible in the landscape were constructed over the last millennium before first European contact. Cultural dynamics of the *longue durée* for the Archipelago link this expansion to the rise of a specific ‘Traditional Kanak Cultural Complex’, with increasing social complexity leading to a general intensification in the use of nearly every part of the inhabit-



able landscape during the second millennium AD, a process unsurpassed elsewhere in the Melanesian crescent. The terraced taro pondfields cannot be studied in isolation from the larger picture of New Caledonia's human history. The island is devoid of the signs of continuous conflict and extensive fortified settlements that are seen in Fiji, for example (Field 2005), so the question of horticultural surpluses, produced for competition in prestige feasting between chiefdoms, must be taken into consideration (Sand *et al.* 2007). Also, the role of taro planting in pre-colonial Kanak societies needs to be addressed by looking at the entire range of former planting traditions. Apart from the well known sacred yam cycle, most other crops have been given just passing mention by European scholars. One case which needs more attention is the link between *Colocasia exculenta* and *Alocasia macrorrhizos*. Fallow patches of *Alocasia macrorrhizos* are regularly observed in long-abandoned fields during archaeological surveys, although this stem-crop is very seldom eaten today by Kanaks, and no large cooking ovens for its preparation can be observed (but see Lagarde *et al.* 2009: 3). Even if this plant is now a negligible source of food, the extent of its wild presence in former sites, and observations made in the mid-19<sup>th</sup> century in different parts of the archipelago (*cf.* Crocombe and Crocombe 1968: 35), testify to the former importance of *Alocasia macrorrhizos* cultivation in New Caledonia (Sand *et al.* 2010: 38). Another case is *Saccharum officinarum* (sugarcane), whose customary importance in past rituals—alongside the dry yam crop symbolizing manhood, and wet taros symbolizing the woman—remains to be more precisely defined (Barrau 1956; Sand 1995: 189).

In Oceanic societies, the wetland taro has always been given lower symbolic status and importance than the dryland yam. The archaeological surveys, across the Grande Terre of New Caledonia, should make us question the respective importance of yam and taro in everyday food consumption during the last 1000 years of Kanak agricultural intensification, before European contact. In some regions of Grande Terre, the extent of taro terracing appears significantly greater than the planting surfaces dedicated to dryland crops. The question of crop dominance, the chronology of pondfield expansion over time, the regional diversity in production systems, and the increasing sophistication of production techniques, will need to be addressed through long-term research programs dedicated to these interconnected topics, if we want to move beyond a simplistic understanding of Kanak cultural traditions in the past.

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