Chapter 9

OF ATOLLS AND GARDENS

An attempt at participant ethno-archaeology in Tuamotu

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In the middle of the Pacific Ocean lies the Tuamotu Archipelago, with its seventy-five atolls sprinkled over an area larger than that of Europe, forming a fragmented set of islands long settled by human populations in spite of the extreme climatic and ecological constraints constantly impinging on their relations with the environment. This string of low-lying islands is strikingly different from its French Polynesian neighbours, and it is precisely these differences which make it a distinct object of study. It is a complex space, comprised of tiny individualised territories in a vast expanse of sea: a few thousand square kilometres of land scattered over nearly two million square kilometres of water!

It was therefore interesting, with reference to the general Pacific atoll system, for us to look at some of the Tuamotu atolls and to analyse, from a chronological perspective, the interrelations between the detectable climatic and environmental variations, and the past and present adaptability of their occupants. Yet, as we will see, the implementation of this general study produced some wholly unexpected results. The researchers’ program, which consisted in rehabilitating the former cultivation-pits was subsequently, and unbeknown to the researchers themselves, diverted from its original purpose by those for whom it was meant before being in turn re-appropriated by them.

Conditions of the study

The general study first of all undertook to collect geo-morphological data on the coral substratum, which were completed by a few datings that made it possible to circumscribe past variations in sea level. With what is known about the average growth rate of the outer reef, we were able to show, first of all, that the emergence of lands allowing continuous theoretical human occupation seems to have occurred, in Tuamotu, no earlier than 500 AD.
It so happens that this period corresponds exactly — with the exception of the Marquesas Islands, which had been occupied for several centuries by then — to the general occupation phase of the eastern Pacific.

The parallel anthropological study carried out on a few specific atolls where ethno-archaeological excavations and studies on ancient occupation sites had already been conducted, consisted in establishing correlations with the environment as it changed over time. It was interesting to see whether certain criteria of habitability, deduced from the sites and/or remains of settlements, could also at a later time be compared — or even correlated in view of classifying the atolls — with the categories normally used by geographers.

While the more-or-less continuous human occupation of a space is clearly and primarily dependent on the food resources available to its occupants, these resources are locally just as dependent on those provided or allowed by the environment as on those resulting from the techniques of exploitation and enhancement employed by the inhabitants.\(^2\) It was possible to think that, in such small spaces, the reconstruction of the human occupation process, one of the basic aims of archaeology, would be incomparably easier. And too, in these relatively closed yet interlinking little areas, modern depredations seem not to have done much harm for the moment.

Although the islanders are still largely dependent on their environment, the evolution of this environment or of the contingencies to which the inhabitants are subjected is harder to detect, especially for ‘prehistoric’ times, in other words for this part of the world: before the Europeans arrived.\(^3\) Here, too, however it was important to make good use of one of the anthropological particularities of Oceania, namely the vigorous ‘oral tradition’, which had long been directly proportional to the social vitality of a place and which, in spite of everything, made it possible to preserve a large amount of knowledge. Even though this oral tradition is now somewhat corrupted, and in some cases obsolete, and even though its ‘depth’ is limited to three generations at best — when it comes to technical information and material culture — the remains have nevertheless proven to be consistent and determining enough to be validly used.

Although limited, collective or even individual memory is still an indispensable support and guidepost. The example of the renewed interest in modern-day tabua (healers also acting on the supernatural as well), who cleverly manipulate cultural information and its present-day transpositions, shows how easily new uses, chronological short-cuts and syncretic creations are accepted by popular consensus. In the minds of elderly Paumotu, the past is amalgamated and lost in an often idealised ‘in former times’ or ‘once upon a time’, which sometimes include the twentieth century. It is therefore necessary to factor in this recently introduced neo-cultural background noise.\(^4\)

**The atolls**

Atolls are what remains of old volcanoes when the mechanisms of erosion, subsidence, eustanism, deformation of the lithosphere and sea-level fluctuations have taken their toll; they are circumscribed by living coral reef, which has gradually reduced them to rings a few dozen kilometres around and projecting a scant few metres above the water.\(^5\)
The reference curve of the average fluctuation in sea level that has gradually been established indicates a regular drop of some sixty centimetres over the last 1500 years, in other words, since 450 AD. However, present or very recent observations suggest a reversal of the process (on the order of one centimetre per year), the causes of which are still under debate (greenhouse effect, El Niño, earth’s natural cycle, for instance), has been under way for several decades at least. This means that any direct correlation between age, outer-reef growth, average sea level and systematic habitability of the atolls remains to be defined, at least for those periods in which sustained human population was feasible. Nevertheless it also proves that, with the exception of the observation time scales, there is quite a bit of room for uncertainty between the deductions that can be made from the geo-morphological observations alone and their actual effects on the island populations. This uncertainty is further amplified if we take into account the extreme variability in the evolution of the purely human contingencies. In fact, it turns out that the distribution of the archaeological traces of human activity presently observed does not reflect the apparent ‘natural’ occupation capacities of these islands and, in any event, does not seem to be connected with the sudden disappearance of specific plant or animal species.6

The Tuamotu archipelago was discovered in 1521 by Quiros, but did not receive further noticeable European visits — if one excepts Roogeveen in 1721 — until the end of the eighteenth century. Here were the last uninhabited islands, not only in the Eastern Pacific, but in the entire world. This explains why these lands were seldom noted by nineteenth-century observers in their journals and logs. It is true that the fluid and relatively ‘discreet’ way these lands were controlled or used by their inhabitants did not fit the known patterns of the time, and thus led to the conclusion of an absence of appropriation or technical culture there. And so the idealised picture of the Polynesian ‘king of the sea, Viking of the South Seas’ grew up and spread, and continued down to our time.

Upon further investigation, the reality of this space proved to be more complex, and, although the occupation of these low-lying islands remained a visual paradox, in reality it exhibited all the logical and rational features of societies which, in order to survive, are obliged to be closely attuned to their environment, especially when it is such a small, limited and fragile one. These features largely determine the way humans occupy their space, which, aside from a few variations, shows little differentiation from one island to another. The people who gradually settled these islands did so in identical fashion, but each time the variations in local parameters — the sea, lagoons, winds — generated a few additional differences.

Agricultural practices and cultivation-pits

Viewed from the open sea, these tiny rings of greenery seem to be entirely covered in a dense forest of palm trees, broken only here and there by nearly desertified spaces. In 1835, Darwin had already remarked that the ocean and the dry land seemed in these places to be locked in constant struggle and that it seemed astonishing that such a meagre barrier was not instantaneously destroyed by the mighty and relentless surge of this immense ocean (Darwin, 1842)
At close range, in spite of the traditional clichés about atolls, blue lagoons and swaying palms, the coconut groves shrink, covering large areas only there where they are truly exploited. Elsewhere a specific vegetation comprised not only of bushes but also trees is once again developing normally and expansively. Introduction of the coconut palm and its generalised diffusion date back no further than the first half of the nineteenth century, but they considerably altered the appearance of these islands, as well as deeply transforming their ecological and human structures.

With resources, an appearance, a population and a habitat that were sometimes very different from those of other southern and central Oceanic societies, and occupying a fragile space whose precarious and clearly inadequate potentialities were preoccupying, this group of islands was in a sense placed in ‘cultural quarantine’. And yet, paradoxically, the marine resources of Tuamotu were those most systematically exploited for (mother-of-pearl) pearl-shells, sea cucumbers and whale hunting. Coconut planting by Europeans — missionaries, traders and administrators — aside from the fact that it generated the beginnings of a market economy, was designed by the new arrivals to compensate for the cultural and agricultural deficiencies of these lands, until then apparently uncultivated, by endowing them with a visible economic utility. As the basis of an evermore artificial economy, coconut plantations had from the outset a considerable impact on the subsequent evolution of these islands, and therefore on the reconstruction of their past. In a few words, systematically bringing under cultivation communally held lands obliged families and their lineages to define in legal and sometimes contradictory terms, the boundaries of certain plots inasmuch as they procured an income or speculative means of monetary exchange that did not correspond, either economically or culturally, to former traditional practices or needs. The administrative ‘districts’ formed from the ancestral matakainanga (domains formerly belonging to a family group that managed marriages and the land, and which were carefully marked out and regulated in space and time), were consequently occupied intensely only during the annual rahui season (the institutionalised communal phase of exploitation), the rest of the time being left almost completely deserted.

Previous generalised occupation of the coral ring is attested by many remains of ceremonial structures used for both socio-religious functions and land management. Such appropriation markers indicate, almost by omission, that these ‘sea-faring’ fishermen also tended to their dry-land territory. In fact they often even practised (their own) forms of organised exploitation of the vegetable resources. The techniques used and their production coincide with the characteristic criteria of horticulture, and that is the word used from the outset to describe the practices of Oceanic peoples, even if they are also often akin to simple forms of agriculture.

A bibliographical search turns up very few descriptions of these growing practices and, as earlier archaeological and ethno-historical investigations mention them only in passing, it was not until we made some direct field observations that they took on a strategic dimension. A few missionary journals mentioned that ‘the islanders dug holes for growing tubers the size of a champagne cork’ or that they ‘buried roots in the ground and some time later came back to gather the product’. Sometimes these ‘holes’ became ‘pits’ in which it was possible actually to grow food crops.
In 1930, the ethno-archaeologist, K.P. Emory, conducted a preliminary and quasi-systematic ethnographic study of the material culture of the Tuamotu islands; it was accompanied by extensive archaeological explorations. At this time Emory inspected a few of these cultivation pits, some of which were still in use. To these, as well as to the corresponding tools, he devoted a few lines of technical description: the first, and until recently, the only references in all the available ethno-archaeological literature. Nevertheless these pits, tangible, concrete, precise components of material culture, whose size is determinant for their quantification potential, never became the object of an individual study. In fact, nearly the same is true of the general study of agrarian remains in the Pacific Ocean.

Found almost everywhere and covering from a hundred or so square metres to several hectares, cultivation-pits are more or less regularly distributed around the inner rim of the atolls. The exploitation techniques that have been pieced together thanks to earlier descriptions are now well known. Briefly, these are large pits dug down to the surface of the water table; the evacuated earth pitched up around the perimeter reaches a height of from two to eight metres, forming a succession of steep hummocks. The adjective ‘brackish’ often associated with their use stems above all from the usual consequences of the abandonment of the pits owing to the establishment of the rahui in districts remote from the village. To the eye, these cultivation-pits are the most numerous, common and in fact largest elementary remains of pre-European human occupation of Tuamotu, and of the atolls of the South Pacific in general. They are a characteristic feature of a true agrarian architecture in any rural landscape, and reconstruction of their food-producing potential attests to the important role they played.

In addition to systematically measuring the shape and area of over a thousand pits, we were able to reconstruct the old techniques by collecting the know-how of a few elderly persons on different atolls who were eye-witnesses or themselves possessors of ancestral knowledge. We where thus able to establish a different image of the old ways of occupying these low-lying islands. Today, monoculture of the coconut tree together with widespread dependency on government and metropolitan handouts have almost totally eradicated the food resources derived from agriculture and the knowledge that went with them.

An experiment in transplanting the past

In view of this almost general loss of know-how and the dramatic dietary deficiencies observed, the discovery, by true ethno-archaeological investigation, of an important autochthonous food-producing potential prompted us to try out these methods. The data we collected provided detailed descriptions of the succession of operations as well as the yields obtained, justifying our decision to get involved and make practical use of the disconnected pieces of information. Piecing together knowledge freshly rediscovered and then reconstituted, in part thanks to the tattered memories of a few elderly inhabitants and in part owing to techniques of investigation borrowed from the human sciences and agronomy, represents a dynamic and stimulating challenge.
The switch from research findings, from the ‘scientific’ sphere, to their concrete application sanctioned by future users is a transformation rarely attempted, not only for ethical, but also purely practical and structural reasons. In the present case, the stakes were even higher because the justification for such an experiment was based on a largely bygone past. In reality it was the simple fact of taking into consideration all the archaeological, historical, environmental, and then sociocultural and agronomical data that, little by little, gave rise to — and defined — the idea of attempting such an experiment, in which separate disciplines appeared effectively to complement each other. Indeed, one of ethno-archaeology’s favourite areas of application and expression is precisely Oceania. By combining agro-pedological and geo-morphological observations with the ethnographic data, we were able to define a ‘virtual’ reality that objectively lay in the past, but which lent itself at the same time to a new genesis. The only real unknown — although we had already had a glimpse of it as well — was ‘quite simply’ how the population was going to accept this sort of cultural transplant, a veritable technological ‘auto-intra transfer’!

We envisaged the experiment first of all as a trial run, taking advantage of the interest, charisma and efficiency of a former village leader; and afterwards as a more global agro-cultural restoration campaign, using audio-visual techniques and mediations whenever possible. For the territorial government, this was also an experiment in verifying the true developmental possibilities of the French Polynesian atolls and could help provide an answer to the economic and social concerns of which they are the object.

Today islanders’ truly rural activity is reduced to its simplest expression: upkeep of the coconut groves is rudimentary at best, if not non-existent. Although it is hard work, the harvest is more akin to gleaning or simple gathering. Spread over the year, these operations occupy only part of the time. And in any event, income is ensured by an artificial subsidy system known as ‘equalisation’, which has nothing in common with the true world price of copra (on the order of one tenth the subsidy level). It appears increasingly clear that this set of measures is a simple socio-economic formula to combat the depopulation of the atolls. But the measures are also limited to exclusively economic or purely financial operations. No alternative involving a minimum level of food production has ever been envisaged or suggested. Aside from the anarchical channels of ‘unauthorised’ enrichment, observed in a few pearl-shell farms, the sociocultural fabric is in a state of almost total disrepair.

Once we had proof that the Paumotu’s ancestors knew how, under well-defined conditions, to cultivate, improve, renew and settle their garden plots here, and that they produced enough food to satisfy their needs, we set up a program to rehabilitate a few old cultivation-pits on one atoll, with the gradual support of a few cultivators and local leaders. Roughly speaking, this program featured a series of attempts at restoring cultivation-pits that had stood abandoned for over a century, and planting them with both traditional and recently imported food-species. The trials were to be carried out and observed over a period of at least two years.

The program got off to a good start, but soon bogged down, at least with respect to the calendar we had drawn up, due to delays in releasing the funds. Fortunately, the parallel program of demonstrations and audio-visual displays enabled us, in spite of everything, to maintain a climate of patient if not completely favourable expectation on the part of the population and the persons more specifically involved.
The village community had seemed at once quite interested and quite apathetic. The innovative side of the project, linking tradition closely with development, was attractive to certain villagers, but the historical void separating them from this tradition was still a very real handicap. Moreover, so many Europeans had already come promising them the moon, advocating one technique after another, that they preferred to quietly wait and see.

Because of both technical and human difficulties encountered on the experimental island, two other locations had to be and were chosen, and this was at the request of their occupants. The new locations presented the advantage of being closer to the village and being the sites of fairly polyvalent activities: rudimentary gathering of copra, but also of seashells for necklaces and various kinds of fishing. Each was under the direction of an active, enterprising and efficient family head backed by a united kin group. After an observation phase of nearly two years — described by some as inactivity — these leaders began to show an interest, based on the content of the agricultural or food-producing possibilities they themselves had assessed. This interest, which had grown almost on its own, also contrasted sharply with the concerns expressed by others, based essentially on the amount of money they anticipated in return for their co-operation.

As the program unfolded, one negative parameter gradually took on an unexpected importance. The thick layer of rich vegetal matter at the bottom of a number of pits was already home to a great many *tupa* crabs (*Cardisoma carnifex*), which initially made serious inroads on the sites' production capacity. The *tupa* ravaged the few taro plants that were left after the initial planting, so that we did not have enough shoots to replant the area planned and, above all, this created problems with the administrative regulations. In the beginning, the plants matured without any noteworthy intervention or difficulty. But as soon as the *tupa* discovered the shoots, it took them only a few days to do serious damage. So a way to combat this unexpected predator had to be organised. Since the generalised abandonment of the coconut groves that had covered between 80 and 90 per cent of the atoll area, the crabs had proliferated quite rapidly in the wet zones and therefore particularly in the abandoned cultivation-pits. The soil, which already favoured organic and biological activity, was quickly adopted by these nearly omnivorous crabs. The earlier regulatory systems, such as the widespread human consumption of these animals, had completely disappeared. Even worse, such was the amnesia and the ignorance, that many people were convinced that the crabs had never been eaten because they are dangerous. This idea, contradicted by old descriptions, comes from the fact that the accumulation of all manner of refuse, in the island agglomerations that have grown up since the second half of the nineteenth century, effectively made the *tupa* unfit for human consumption. But wherever the population density, and therefore the amount of refuse produced, is not excessive, their content can be assimilated, and they are indeed edible and eaten. This is true in many archipelagos as well as in the other South Pacific atolls.

Obtaining taro shoots, a problem that arose in the first trials, was another obstacle. Despite the presence, in the early stages, of a market gardener from the Austral Islands — he had set up after the 1983 cyclones — willing to sell us his own shoots, their number fell far short of the hundreds we needed. Those we procured from a farmer in Tahiti could not be shipped owing to the strict application of a phytosanitary regulation theoretically designed to
protect the Tuamotu atolls, as the fumigation normally and obligatorily done on site by no means guaranteed plants would not be infected with certain diseases. Further information and analyses showed that the near totality of the islands of French Polynesia were already contaminated. But as the phytosanitary services could not guarantee that the shoots were innocuous, their transfer from island to island was not authorised. The difficulties involved in finding another source that met the phytosanitary and technical requirements meant that our only sources of supply were the residual shoots and those produced in our own pits.17 Nevertheless, these parameters were an instructive indicator, for they gave a good idea of the time needed to plant the tens of thousands of square metres exploited, which were certainly close to the parameters regulating the size of the growing pits in former times.

These problems notwithstanding, I later discovered that a dozen households in the village had, of their own accord, begun very quietly reconstituting small vegetable gardens in which taros accounted for a large portion of the produce. The little study we did and the videos we taped at the time showed that some of these ‘secret’ gardens had been going for over a year and that some were even in their third production cycle.

Our experimental program — which in my opinion had had a few hiccups — had in fact taken hold elsewhere and of its own accord, independently of us, since we knew nothing about it. This was in large part due to the video sessions we had organized on several occasions at the town hall. The relatively detailed technical and comparative information provided at these showings assuaged people’s doubts and hesitations, and prompted them to carry out their own, almost clandestine, experiments. So as to avoid the ‘shame’ attendant in this rural world on quitting or failing, each household preferred to keep their own experiment a secret. Initially the undertaking proceeded discreetly. Then, as the results proved positive, the plants were gradually displayed. In time, the front yards, usually restricted to ornamental plants, were transformed by these new family vegetable plots, which, little by little, overflowed their backyard enclosures and began to expose themselves to passing glances.

A few personal innovations in the techniques of plant preparation or composting had been imagined and tried out by some, revealing to us at the same time, behind the individualization processes, the mechanics by which techniques and know-how are personally appropriated. Last of all, it should be noted that, for those attempts that were crowned with success, the master gardener’s display sometimes took on an ostentatious character, showing an additional degree of skill that enhanced their standing in the eyes of the community.

**Conclusion**

Beyond the successive difficulties, which are after all part of any experiment in development, the attitude changes or the initiatives on the part of a few people offer food for thought. The experiment shows that the successful introduction of an outside element into a functioning system has, at the very least, to answer to contingencies that are often much more complex than — or entirely different from — those one would have thought, whether one is dealing with people, nature or their common environment. Secondly, it is interesting to see that,
while people reacted in terms of individual motivation, the determining factors turned out to be the technical and comparative details to which the population has full access.

In the case of our program, originally developed on the basis of ethno-archaeological observations and reconstitutions, but specifically adapted to the rural environment and subsequently to the area of agronomy, it is interesting to note that, even though it was diverted and slowed down by external problems, it nevertheless went ahead, not only unbeknown to me, but in a space that had not been anticipated.

The challenge of ‘trying to revive the past’ in order to demonstrate that, even in a small, isolated enclave, it not only held potential but provided a precise answer to certain needs was accepted and at the same time diverted. The very targets of the program, adopting a prudent, circumspect pedagogical attitude, appropriated the experiment, and they did it in a much simpler way than we had expected. The productivity and yields of the gardens they could make for themselves became very clear to them as soon as the advantages could be isolated and identified. Once they had acquired the necessary techniques, their individual approaches both united and differentiated them.

To be sure, the simple technological, and even economic, demonstration is only the first step, a necessary one, but not sufficient in itself. For such an undertaking to succeed, it must then fit into the cultural fabric, into the pathways and spaces conceivable by the community it addresses, and then go on to achieve true autonomy.

The way this appropriation took place, in Ana’a atoll particularly, as well as the requests arriving today from other atolls, are conclusive and comforting. They teach us that it is not enough to propose examples of development bolstered by an arsenal of irrefutable technical and economic arguments for them to be accepted. Sociocultural regulators intervene and by creating an obstacle here, a limit to excesses there, can sometimes also become amplifiers.

The entirely unforeseen fight against the taro-eating crabs also shows how chains of ecological regulation are constantly at work. Changes to the occupation conditions of the atolls combined with eating habits constantly raise new problems, the ones flowing from the others. One of the specificities of the rural world and of agronomy is having to take this into account. Many plans and experiments motivated solely by the logic of technical or economic rationality have foundered because such social and environmental parameters were ignored.

The exemplary situation of the Tuamotu Archipelago shows that the inertia of the past exists: one can complain about it or put it to use. All evolution, be it environmental, human or social, has a ‘history’ which literally cannot be circumvented. By taking this history into account, the Tuamotuans will be able to move towards an optimal and autonomous recovery of their own potentialities.

This project was originally intended as a local demonstration of the agronomic capacities of the atoll soils; unbeknown to us, however, it spread to a good number of households as soon as proven techniques were put to use demonstrating its success. What had been programmed for at best the medium or the long term took hold in other places, in other ways and faster than we had planned. By reestablishing a dynamic, active connection with their past, the Paumotu not only rediscovered part of their roots, they gave new value to a past that could also become a legitimate source of pride.
Footnotes
1 This article is based in particular on work carried out during different missions conducted by CORDET and FIDES (MEDETOM) and then within the ATP (Centre National de la Recherche Scientifique) project, ‘For a history of the environment and natural phenomena’.

2 In an environment like that of the low-lying Tuamotu islands, the impact of, first of all the open sea, then the lagoons on the emerged land, although synchronous with human presence, do not respect the same variable orders of magnitude. Even though the decisive parameter of sea level acts on a scale of thousands of years — while it is only a few decades for the shell fish and fish (benthic and halieutic) populations — the corresponding time scale of human populations is a mere few centuries, by approximately two-hundred-year chunks. Finding the smallest common multiple for observing these respective time scales is therefore the challenge that this particular space obliges us to make. The ecological parameters are so tightly intertwined with those governing the tiny human groups occupying this space that there is no choice but to try to understand them in a complementary fashion.

3 The evolutionary gradient visible from archaeological data and ethno-historical observations seems to have remained relatively stable in these islands from the first landings down to continuous occupation. Aside from a few cases, whether in the high or the low-lying islands, successive technical changes, the key to establishing prehistoric ethnological chronologies, are almost impossible to isolate. We still do not know exactly the range of uses to which the basic materials found on an atoll were put. These are restricted to coral or shells hardened by calcification, to bone or mother-of-pearl, to name only the hard materials capable of lasting any amount of time in an exclusively chalky soil. Under the best possible conditions of preservation, in a dry, airless place, the lifetime of plants and organic material is at best little more than a hundred years.

4 This explains why, in many cases, aside from collecting ethnographic information on the past or its present-day remains, archaeological methods will be needed to identify and order certain phases of activity. In particular, the periods before European arrival, which was recent in this part of the world, have been forgotten.

5 In principle there are several parameters which determine whether or not people can settle for short or long periods of time: whether or not the vertical deformation of the lithosphere and the fluctuations in the sea level, climatic and volcanic cataclysms, evolution of the madrepores, the pedology and the flora enable the coral rim — especially on the reef — to afford a minimum of protection against the onslaught of the sea, thus allowing the formation of soils necessary to the implantation of the different life forms. No human settlement of any kind can become stable until this transformation is sufficiently advanced.

6 For the sake of comparison: the floral dynamic observed on most of the atolls since the 1983 cyclones accounts for a buried paleohumus enriched horizon. The intensity of this dynamic is such that not only has it withstood the episodic cyclones, it also corresponds to a reappearance of the state that existed prior to the transformations of the nineteenth and twentieth centuries, appearing even beneath refuse-strewn and sterile soils. The generalised presence of at least one paleosol can be explained in part by the recently named ‘endo-upwelling geothermic’ phenomenon, which explains the occasional welling up of certain biochemical nutrients through the porous coral substratum (Rougerie and Wuathy, 1986); this phenomenon naturally promotes a certain development in the vegetation.

7 The present-day administrative districts coincide roughly with the space of the former matakainanga.

9 See Montiton (1874).
10 See Fierens (1873).
11 See Moerenhout (1937), Lucett (1854).
12 See Emory (1975).
14 The average visible depth ranges from 2.5m to 4m, depending on the pit; this corresponds to the average stable level of the underlying freshwater, a freshwater lens, which is linked to the volume of rainwater trapped after percolating through the substratum under the coral ring.
15 Another frequent reason is ignorance of the limited thickness of the pod of freshwater (see note 14) that floats on the surface of the brine (following the Ghyben-Hertzberg principle). If the excavation is too deep, the pit goes through the thin layer of freshwater and you wind up with brine or brackish water.
17 These therefore had a lower theoretical rate of reproduction and proliferation.