

# A preliminary vertebrate palaeontological survey of the granitic Seychelles islands

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*Abstract.*— The results of a reconnaissance palaeontological survey are described, with an island by island review of potential fossil localities within the granitic Seychelles. Lowland/montane marsh and cave (boulder field) localities were examined, test pits dug on all sites and details recorded. The first giant tortoise and avian fossil material within the granitic Seychelles was discovered, although in general the localities were poor in both vertebrate remains and preservation quality.

*Keywords.*— cave, fossil, marsh, terrestrial snail

## INTRODUCTION

The granitic Seychelles comprise 41 islands and islets situated between 4-5°S and 55-56°E (STODDART 1984). The islands are isolated, lying 930km from Madagascar to the southwest, 1590km from East Africa to the west and over 3300km from India to the north. The Seychelles have a complex geological history and, uniquely for oceanic islands, they are derived from the Gondwanaland continental landmass rather than a result of volcanic activity (PLUMMER & BELLE 1995). The origin of Seychelles can be traced from the genesis of the South-West Indian Ocean Ridge 200 Mya, when Africa began to separate from Antarctica, forming the south-western Indian Ocean (SADDUL 1995). Between 190-135 Mya (late Jurassic to early Cretaceous), a Madagascan block, with Seychelles and India attached, drifted from Africa creating the Mozambique Channel, and around 120 Mya, it drifted south to Madagascar's present position (COURTILLOT 1999). Primarily due to the formation of the Carlsberg Ridge (DYMENT 1998), between 85-80 Mya, India and the Seychelles separated from Madagascar and drifted north. The Seychelles then separated from India *ca.* 60 Mya (DUNCAN & RICHARDS 1991) and the islands have remained isolated ever since. They have, however, been subject to fluctuating sea level changes, and during Tertiary sea level low stands, their landmass may have been as much as 130,000km<sup>2</sup> (HAQ *et al.* 1987; ROHLING *et al.* 1998), compared to the present 455km<sup>2</sup>; thus only the former mountain tops now remain above sea level.

Potentially, therefore, the palaeontology of the Seychelles may be millions of years old. To date, however, bones and teeth referable to *Crocodylus porosus* (GERLACH & CANNING 1994; GERLACH 1997) (Table 1) discovered on Mahé represents the only known vertebrate fossil material from the granitic Seychelles, although there is some doubt as to

the provenance of some of this material (see GERLACH & CANNING 1994; Table 1). This scarcity of fossil remains is common to many oceanic islands, primarily due to rapid chemical decomposition (OLSON & JAMES 1982, TENNYSON & MILLENER 1994, WORTHY & HOLDAWAY 1993), particularly relevant to weathered granite sand and the subsequent production of acidic environments, the impact of scavenging, and for topographical reasons. The steep, mountainous nature of the islands coupled with the absence of suitable sedimentary repositories encourages rapid and high energy water run-off (OLSON & JAMES, 1982), thus the majority of vertebrate carcasses are presumably washed out to sea. Furthermore, true soils are very poor for fossil preservation, because they, as opposed to the sediments referred to in this paper, are a result of soil-forming processes in which the break down, transformation, accumulation of minerals and organic matter has occurred, and they have remained stable due to plant roots, compaction etc (see BOGGS 1995). Sediments are generally unstable and uncompacted, with few or no plant root intrusions, and it is within sediments on oceanic/continental islands that almost all fossil material is found.

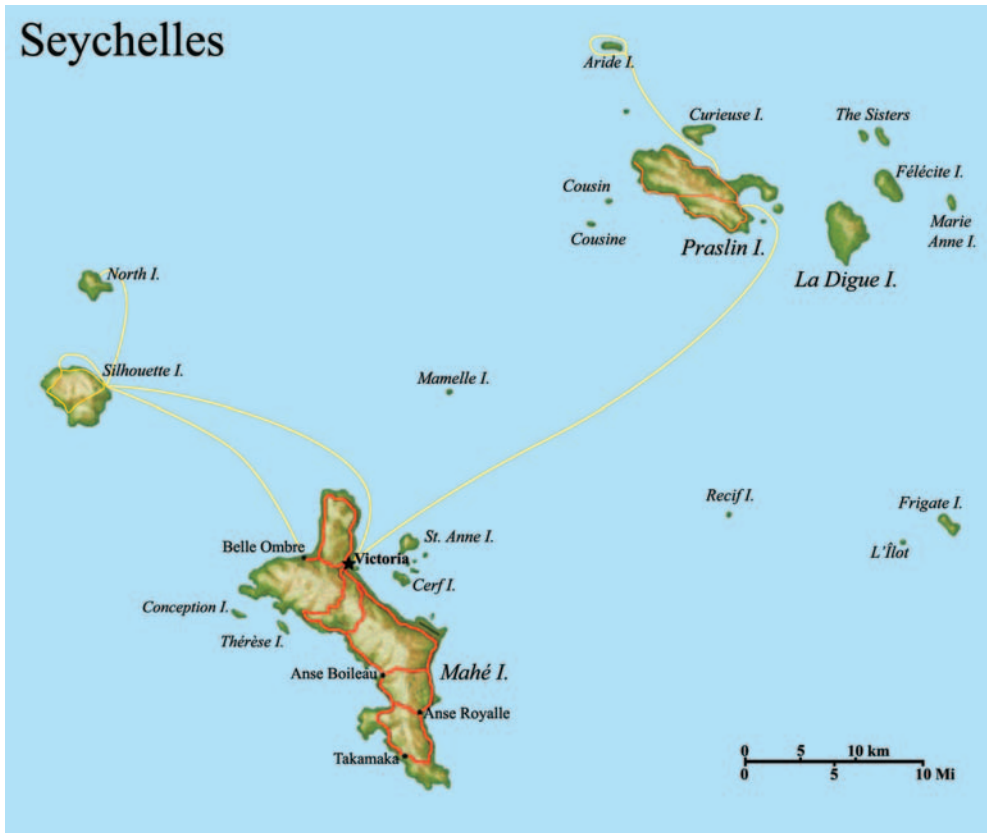


Fig. 1 The granitic Seychelles islands (1:10,000) and the inter-island and overland routes used during the survey.

## METHODS

In order to search for fossil bearing localities and vertebrate fossil material, in October–November 2001 I undertook a reconnaissance survey of all of the main granitic islands (Mahé, Silhouette, Praslin, La Digue), as well as the off-shore granitic islets of North Island, St Anne and Aride. This included searching sedimentary basins, e.g. lagoonal deposits, montane and low-lying plateau marsh deposits and boulder field (cave) localities for vertebrate remains by means of small-scale preliminary digging. Localities that were subject to construction activity and agricultural/plantation use were also examined in order to ascertain the potential of searching disturbed sites. The preservation of terrestrial snail shells within a locality was noted as their presence can provide important pointers for finding vertebrate remains. Results are presented here, together with comments on the potential of finding other fossil yielding localities within the archipelago. Surveying was planned using 1:10,000 and 1:5,000 (North Island) ordinance survey maps published for the (Directorate of Overseas Surveys) Seychelles Government. Minimal tools were carried for preliminary research, but these included caving lights, small trowel and fork, collecting bags, compass clinometer, GIS tracker, measuring tapes and photographic equipment. Non-destructive palaeontological methods, e.g. taphonomy, spatial analysis etc, were employed in order to disturb localities as little as possible. Due to the logistics involved, fine sieving apparatus was not taken on this survey, but will be utilised in planned future work. As a result of this preliminary reconnaissance, further fieldwork on the Seychelles is scheduled for summer 2005.

## RESULTS

### *Mahé*

Mahé is the largest island of the Seychelles group, being 27km long, 8km at the widest point and having an area totaling 154km<sup>2</sup>. The island is dominated by a tall mountain range with the highest peak, Morne Seychellois, reaching 905m above sea level. Numerous large rivers have eroded the mountains forming steep sided valleys, becoming slow moving and meandering on plateaus and forming deep deposits of silt in sedimentary basins. Substantial delta systems have been created, particularly where the barrier of a coral reef has created a lagoon, e.g. Police Bay, and here water energy is extremely low. Some of the larger and more assessable localities of this type were examined and preliminary test sites excavated. One potential montane site was also examined near the summit of Morne Seychellois.

*La Plaine 4°39'02 S, 55°24'04 E.*— La Plaine is situated on the central west coast of Mahé and covers an area of approximately 550 x 300m. Mangrove dominates the area, which is divided by numerous watercourses. Sediment banks are high, reaching a depth of 2m+, and comprise coarse sands fining upwards to silt. Invertebrates and crabs are extremely numerous, and much of the visible bioturbation is caused by crab burrows. Test pit digging was undertaken on exposed banks and revealed degraded indeterminate terrestrial snails only.

*Grand Anse 4°40'08 S, 55°27'03 E.*— An examination was undertaken at the junction of Riviere Dauban and a small delta at Grand Anse (approximately 400 x 300m). Much of the marshy area has been reclaimed and forms part of a coconut plantation, agricultural

farm, timber company and large hotel. The majority of the strata comprised true soils and some spoil heaps were present. The spoil heaps were examined and test pits dug without result.

*Trois Freres 4°38'01 S, 55°26'05 E.*— The footpath leading to Trois Freres Cross, near the summit of Trois Freres in the Morne Seychellois National Park, passed over a series of montane watercourses and small marshy deposits; despite the dense covering of marsh plants, some exposed sediments were present. Water run-off was notably high and eroded gullies exemplified the high energy involved. Small test digs produced no fossil material, almost certainly due to the steep gradients and rapid run-off of water.

*Anse Royale 4°44'05 S, 55°31'00 E.*— An examination was made of Anse Royale because it is the only site to have yielded vertebrate fossil remains prior to this survey (see Table 1; GERLACH & CANNING 1994; GERLACH 1997), though precise details as to where the fossil material was collected are unavailable. Only a small area of marsh now exists (approximately 500 x 30m) while the remaining plateau is developed or comprises coconut plantation. Mangrove and marsh plants form dense thickets, thus access was limited. Where sediment had collected, it reached depths of 1m+, but unfortunately, the sediment was contaminated by recent human refuse, even at depth, and unsurprisingly, no fossil material was found.

*Anse Poules Bleues 4°44'06 S, 56°27'06 E.*— Much of the channel of the Riviere Anse aux Poules Bleues and of the delta entering the lagoon of Anse Poules Bleues is under cultivation, particularly with coconut plantation. Only a very small 10 x 20m area of marsh was discovered and this was overgrown with marsh plants. Where exposed, sediments comprise coarse fining upward sands and silt reaching 0.5m+ in places. Test digging produced no results. This area was named after a probable endemic species of purple swamp-hen *Porphyrio* sp., which was locally called the poule bleu, but had disappeared by the late 18th century without being scientifically described (GERLACH 1997),

*Anse Intendance 4°46'09 S, 55°30'00 E.*— This marshy mangrove delta is situated on the southwestern edge of Mahé and covers approximately 500 x 200m. The delta is completely surrounded by coconut plantations and made ground. The delta is fed by the Riviere Intendance and evidence derived from undercut banks suggests that water energy is periodically high. Crab and invertebrate burrows are numerous and dense mangrove and marsh plant cover dominate the area, but some exposed banks of sediment are present. The sediments reach 1.5m+ in depth and comprise fining upward coarse sand and silt. Test digging only revealed badly degraded indeterminate terrestrial snail shells.

*Police Bay 4°48'00 S, 55°31'03 E.*— Police Bay is a marshy delta and lagoon system at the southern most tip of Mahé and covers an approximate area of 400 x 400m. The delta is fed by the Riviere Grand Police and forms a permanent lake at the northern limit. The river system is large and, due to the presence of undercut riverbanks, the energy is assumedly high at certain times. Large numbers of crab burrows are present and there is much evidence of other invertebrate bioturbation, e.g. sediment casts on the sediment surface. Mature forest and mangrove dominate parts of the delta and marsh plant cover is exten-

sive. The sediments are deep at 1.5m+, and comprise coarse to fining upward sand at the rivers edge to silts in the low energy lagoon edges. Test digs revealed some degraded terrestrial snails but no vertebrate material was recovered.

*Fossil potential of Mahé.*— Moderate to high. Due to the size of the localities on Mahé, further more intensive work is essential, particularly when dealing with deep sediment areas. Mechanical machinery would prove useful to dig through the surface layers, which may have accumulated much more rapidly in recent times as a result of deforestation and subsequent erosion. Other marshy localities not examined during this survey such as Anse Marie-Louise and Anse Takamaka could also usefully be investigated. Further key localities are the inland cave systems on Mahé. Access to these during my visit was prohibited due to the potential disturbance of nesting endangered Seychelles cave swiftlets *Aerodramus elaphrus*, but when examined out of nesting season, these sites may prove productive.

### **Silhouette**

This circular island, the third largest within the Seychelles, is situated 19km off Mahé's northwest coast, and is approximately 5km x 5km and covers 20km<sup>2</sup>. Silhouette rises to 740m above sea level and is probably the least spoilt of all of the Seychelles' granitic islands.

*Mare aux Cochon 4°28'03 S, 55°13,09 E.*— The Mare aux Cochon is a montane marsh locality covering approximately 1000 x 300m. The area is badly degraded with introduced exotic trees and plantation. True soils occur to at least 2m, as spoil heaps indicate previous agricultural digging activities and the holes are still visible. Marsh sediments exist with typical marsh plant cover. The area is extremely wet and, in combination with a dominance of true soils and abundant tree cover, proved difficult to work. No fossil material was discovered.

*Bat cave A, La Passe 4°29'02 N, 55°15'025 E.*— Situated at the base of Mont Poules Marrons, this cave locality has been created by undercutting of fallen/eroded granite boulders. Sediments are uncompacted and comprise silt to fine sand, with varying depths ranging from 10-50cm. Sediments are dry and loose deep within the system, but more compacted with minor root intrusion nearer the entrances. Test pits were gently dug using a small fork. Complete and partial shells of the terrestrial snail *Stylodonta unidentata* and small fragments of badly degraded carapace of the giant tortoise *Aldabrachelys/Dipsochelys* sp. were discovered (Table 1) at depths from 5-15cm. The specimens were bleached white (Fig.3) and extremely fragile, indicating that they may have been subject to chemical leaching.

*Fossil potential of Silhouette.*— Excellent. The discovery of vertebrate material in a cave system, and a number of other potential low-lying plateau areas awaiting investigation, indicate that Silhouette could prove a productive source for future work.

### **North Island**

This small islet is situated approximately 7km off the north coast of Silhouette. It



has three separate peaks, of which the highest, Grand Paloss, reaches 180m. The peaks are situated on the central south, south-eastern and central to northern coasts, and plateaux is centred around the west coast and central south to east coast. The central marsh covers an area of approximately 150 x 100m (Fig. 2). The outer edges of the marsh are covered by dense growth of marsh plants, which become thinner and more stunted toward the centre. Sediments reach a depth of 1-1.5m and comprise fining upward silty sand with a brecciated basal layer of coral fragments and granite.



Fig. 2 North Island central marsh view looking east. Inset: the author with the discovery of the first vertebrate material.

*Central marsh 054°E; 142.5°N.*— (Fig.2) During my visit, North Island was being developed for the tourist industry and heavy machinery was already in situ. The western edge of the marsh had been partially disturbed by heavy plant, which had removed the top 30cm including the covering vegetation. Two test pits were excavated and the first fossil vertebrate material was discovered (Fig.3). Test pit 1 (6m from the centre of the marsh) produced fossil material at a depth of 30cm, all of which (10 specimens) comprised skeletal elements of giant tortoise *Aldabrachelys/Dipsochelys* sp. (Table 1). None of the material was articulated, but it was generally well preserved and undamaged, indicating that individuals had probably died within close proximity of the marsh and had not been transported via water as disarticulated elements. The disarticulated nature of the material may be a result of mud churning by wallowing tortoises. Test pit 2 (4m from the centre of the marsh) produced more material but at a greater depth (50cm). Of 15 elements collected, 13 are referable to giant tortoise *Aldabrachelys/Dipsochelys* sp., whilst a cranium and partial sternum are referable to the booby *Sula sula* and fregate bird *Fregata minor* re-

spectively (Table 1). The latter two species no longer breed on North Island, although seabirds were reported to do so in the past (Hill *et al.*, 2002).

*Fossil potential of North Island.*— Excellent. The discovery of the first sub fossil avian material on the Seychelles has very important implications for future work.

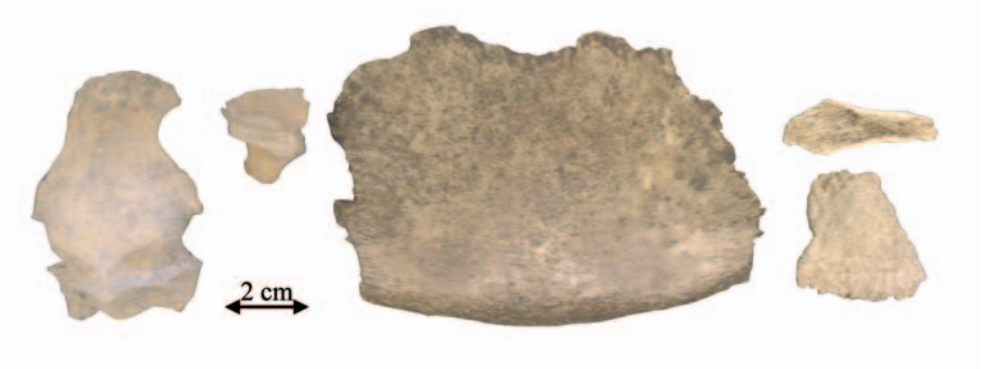


Fig. 3 Subfossil material discovered during the survey. From left to right: Cranium of *Sula sula* North Island; partial sternum of *Fregata minor* North Island; carapace fragment of Giant tortoise *Aldabrachelys/Dipsochelys* sp. North Island; carapace fragments of Giant tortoise *Aldabrachelys/Dipsochelys* sp. Bat cave A, Silhouette.

### Praslin

Praslin is the second largest island of the granitic Seychelles, being 12km long by 5km wide and covering 37km<sup>2</sup>. Its highest point on the land is Fond Azore at 367m. The island is quite mountainous, with minor areas of lowland plateaux confined to the coastal regions in the south, northeast and northwest. Unfortunately, time was limited during the visit and only the briefest of surveys could be completed.

*Vallée du Mai* 4°19'09 S, 55°44'00 E.— Within the base of Vallée du Mai, numerous small watercourses have undercut the banks to some depth and an examination was carried out on the exposed surfaces. Badly degraded terrestrial snail shell fragments were recovered but no vertebrate material. True soils dominated the area and sediments comprised only a minor component of the strata.

*Anse Marie-Louise* 4°21'01S, 55°45'08 E.— This marshy area is situated within a small delta fed by the Riviere Anse Marie-Louise and is approximately 200 x 300m in size. Large trees create a dense canopy in places, with intermittent small shrubs and mangrove. Sediments are deep at up to 1.5m thick. Bio-turbation is evident with small invertebrate casts on the surface and large numbers (~3 per square meter) of crab burrows, some in excess of 20cm in diameter. Test pits revealed the degraded but abundant shell remains of terrestrial snails. No vertebrate material was discovered.

*Fossil potential of Praslin.*— Moderate. Praslin may prove promising with a more extensive search of low-lying plateaux areas particularly the marshy areas of Anse Madge and west of Grand Anse. Development, however, has already reduced the chances of discov-

ering new localities on some of these sites.

### ***La Digue***

La Digue is the fourth largest island at 5.5km long by 3.5km at its widest point, covering an area of approximately 10km<sup>2</sup>. The island is dominated by the Nid D' Eagles, the highest point at 333m, in so much that plateau only occupies a small area of the west coast.

*La Mare Soupape 4°21'05 S, 55°49'09 E.*— This marshy area is found at the junctions of a number of small rivers draining off the Nid D' Eagles and covers an area of approximately 500 x 500m. It comprises mangrove, mature exotic forest and open marshland. Much of the sediment has deep root penetration and comprises true soils, which made digging difficult. Marsh sediments range from 50cm-1m+ deep but thick marsh plant covers much of the area. A number of test pits were dug up to 1m deep without result.

*Fossil potential of La Digue.*— Moderate. Due to lack of time, La Digue was not thoroughly examined and further work might prove promising.

### ***St Anne***

St. Anne is the largest of 6 small islands lying off the northeast coast of Mahé. It covers 2km<sup>2</sup> and forms part of the St Anne Marine National Park. Its highest point rises to 250m, with a sandy plateau on the southwest coast.

St Anne has been subject to substantial anthropogenic activity, with much of the plateau disturbed and built over. Large oil storage containers and other buildings are present and the island is presently being developed for the tourist industry. The remaining forests comprise introduced exotics and disused coconut plantations. A marshy area situated on the east side of the islet at the base of the gradient was examined. The sediments were up to 1m deep, comprising fining upward sandy silt deposits. Basal layers were brecciated with coral fragments and small <10cm granite boulders. A large number of well preserved *Stylodonta unidentata* terrestrial snail shells were recovered but no vertebrate material.

*Fossil potential of St Anne.*— Very poor. The past and progressing destructive activities by man have reduced the potential of finding any fossil material. The introduced exotic plants and coconut plantations have also made access to potentially useful areas impractical.

### ***Aride***

This is the most northerly of the granitic Seychelles islets, situated approximately 50km northeast of Mahé and 16km from Praslin. It is 1.5km long by 0.5km wide. The highest peak of Gros La Tete rises to 135m above sea level. Aride is an important world site for breeding seabirds, with probably the largest populations of lesser noddy *Anous stolidus* and white-tailed tropicbird *Phaethon lepturus* in the world, as well as dense populations of many other seabirds (STODDART 1984). The islet also hosts the world's densest populations of terrestrial lizards, most notably large skinks (CHEKE 1984). Marshy areas and tall forest exist on the Plateau, with the forests thinning and become more stunted on



the gradients.

On the plateau, the sediments are deep and compacted in the forested areas with dense and deep root penetration, the majority of which have become true soils. On the gradients, the sediments are thinner and less compacted but mixed heavily with guano and surface leaf litter. The marshland is covered in vegetation, with deep root penetration forming rich humic layers. Large numbers of sea bird corpses were concentrated in catchment areas such as the bases of trees on the slopes, edges of the marsh and the junction of the gradients with the plateau. Dense populations of skinks, in particular *Mabuya sechellensis* and *M. wrightii*, scavenged the corpses and thus many were disarticulated. The examination of sites was limited, but no fossil material was discovered.

*Fossil potential of Aride.*— Very poor. Too many scavengers are present to expect any large scale burial of specimens and, given the large amount of tree/plant cover, root damage is likely to rapidly destroy buried specimens due to root mineral extraction.

Table 1. List of vertebrate fossil material collected during this and previous palaeontological surveys of the Seychelles

| Species   | Locality                            | Element type and number (n)  |
|---|-------------------------------------|--|
| <i>Crocodylus porosus</i> (Gerlach & Canning 1994; Gerlach 1997)              | Anse Royale, Mahé<br>*Presumed Mahé | skull (3)*; maxilliae (2); pre-maxilliae (3); lower jaw (2); jugals (2); teeth (5) |
| <i>Alabrachelys/Dipsochelys</i> cf. <i>arnoldi</i> . (Gerlach & Canning 1998) | Anse Royale, Mahé<br>*Presumed Mahé | carapace (2)*; vertebra (1); humerus (1)   |
| <i>Alabrachelys/Dipsochelys</i> sp.   | Central marsh, North Island         | tibia (1); scapula (1); carapace (17); indeterminate fragments (6)                 |
| <i>Alabrachelys/Dipsochelys</i> sp.   | Bat Cave A, La Passe, Silhouette    | Carapace (7); indeterminate (1)  |
| <i>Sula sula</i>  | Central marsh, North Island         | Cranium (1)  |
| <i>Fregata minor</i>  | Central marsh, North Island         | Sternum (1)  |

## CONCLUSION

Two main conclusions are suggested by this short reconnaissance survey of the Seychelles. Firstly, the existence of an array of definite and probable subfossil localities on the Seychelles has been ascertained and potentially more are waiting to be discovered, with the discovery of the first bird fossils (albeit extant species) on North Island exemplifying the possibilities of finding undescribed bird species. In a situation similar to Mauritius and Réunion (HUME *unpubl.*), caves and marsh localities appear to create the right criteria for fossil preservation, but it is apparent that the marsh localities situated some distance from steep gradients have a better chance of retaining fossil material. The recovery of terrestrial snail shells in many localities is encouraging, as their presence suggests that bone material may be preserved as well. The abundance of scavengers such as crabs and lizards, however, is less encouraging as they can seriously influence the preservation

of smaller (<30cm) vertebrates in marsh localities, although cave material should be less affected. Palaeontological material collected during this study and previously (see Table 1), indicate that it is of comparatively recent age, i.e. Holocene (*ca.* <2000 yr.) and categorised subfossil, having undergone little or no diagenetic changes. Although this palaeontological study is not conclusive, it may be expected that the likelihood of finding fossil material of greater age is unlikely.

The second conclusion is one of deep concern. Most of the lowland plateau areas are degraded and are being or have already been lost to tourism, agriculture and community development. Very recently, a potentially important marshy deposit on Praslin has been destroyed by the extension of an airstrip. Such developments, which are also accelerating on other Indian Ocean islands, e.g. the Mascarenes, are removing any opportunity to examine pristine sites. This is extremely regrettable as even the limited material collected on this short reconnaissance has already been analysed for DNA (albeit unsuccessful) for scientific research involving Seychelles giant tortoise taxonomy (e.g. PALKOVACS *et al.* 2002; AUSTIN *et al.* 2003). It would be a great loss to science if the opportunity to discover more material were no longer to exist.

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