



Status of the Estuarine Crocodile

(*Crocodylis porosus* Schneider 1801)

in Vanuatu



by
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and David Esrom

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Executive Summary

This project was carried out to assess the current status of the estuarine crocodile in Vanua Lava, the only island in Vanuatu known to have a breeding population. The study was carried out by a combination of a site visit coupled with interviews with villagers and the local distribution of a questionnaire.

The findings show conclusively that there are very few crocodiles remaining on the island, perhaps only two or three. No young ones have been seen for several years. It thus appears that breeding has ceased and if this is the case then the crocodile will become extinct in Vanuatu. Previously high numbers of crocodiles appear to have been decimated by a severe cyclone in 1972. Some survivors of this event were subsequently shot, and coupled with natural mortality perhaps increased by later cyclones, this sequence of events appears to have brought the crocodiles down to a nonviable population size. The available habitat for the crocodiles appears to be extensive and in good condition.

There is a strong belief in Vanua Lava that crocodiles were accidentally introduced to the island in the mid-19th century. There is no independent corroboration for this. However they came to be there, they are not popular. They undoubtedly eat domestic animals and have recently begun to attack people. In view of the expense and difficulty of attempting to build up the crocodile population, and that it would be unpopular amongst the islanders, it is recommended that nothing be done to attempt to save the crocodiles from probable extinction. If they were to become extinct this would mean a shrinkage of the crocodile's extensive range, as Vanuatu is the easternmost limit of this range.

1. Introduction

1.1 Overview of Crocodile Distribution, Status and Biology

The estuarine crocodile (*Crocodylus porosus* Schneider 1801) is widely distributed from the east coast of India to the Southwest Pacific. Within this range, it occurs in Sri Lanka, Bangladesh, Burma, Thailand, Malaysia, Cambodia, Vietnam, Philippines, Indonesia, Brunei, Papua New Guinea, northern Australia, Palau, Solomon Islands and Vanuatu. Thus, Vanuatu is at the easternmost limit of this extensive range, as seen in Figure 1.

The estuarine crocodile is classified by the International Union for the Conservation of Nature as **endangered**, meaning that it is liable to become extinct unless effective protective measures are taken (IUCN, 1982). Throughout much of its range, the crocodile has disappeared or become severely depleted in areas where it was formerly abundant. It has disappeared completely from west India, Singapore and southern China. The causes of these reductions are hunting, mainly for its valuable skin, and loss of coastal habitat through land reclamation schemes. At present, there are considered to be adequate and secure population numbers only in parts of northern Australia and New Guinea.

The estuarine crocodile occurs mainly along sea coasts, especially in brackish areas such as mangroves and around river mouths. It may, however, be found upstream in major rivers and in freshwater swamps. Females lay eggs, from 25-90, in large mound-nests which they build from a variety of living and dead leaves, branches and twigs. The hatchlings eat mainly crustaceans, insects and small fish whilst adult animals take successively larger animals and vertebrates as they become older. Large crocodiles can attack and kill cattle and horses. Males become sexually mature at around a length of 3.2 metres (about 16 years old), whilst females reach maturity at around 2.2 metres (about 10 years old). The largest crocodile recorded apparently reached nine metres.

1.2 Crocodile in Vanuatu up to the Early 1980s

Information about crocodiles in Vanuatu can be found from three references: Dickinson (1981), IUCN (1982) and Luders (1983). The IUCN account is based on Dickinson's information.

In Vanuatu, the crocodile has been recorded sporadically from Malakula, Santo and Malo. The only breeding population recorded has been from the Port Pateson area of eastern Vanua Lava. The accounts of Dickinson and Luders are at variance over the status of the crocodile in Vanua Lava. According to Dickinson, the population was perhaps up to 50 animals in the early 1980s. According to Luders, the crocodile population was decimated by cyclone Wendy. This struck the island on 2 February 1972, with wind speeds up to 220 kilometres per hour. Much or all of the crocodile areas were inundated by rough seas and an adjacent school was totally destroyed. Luders estimated that the crocodiles were reduced from perhaps 200 animals to a few individuals at this time.

According to his report, crocodile numbers had never recovered and only sporadic sightings were subsequently reported by local villagers. Prior to Cyclone Wendy, sightings were a daily occurrence and tracks were to be seen abundantly along the foreshore in the central and northern parts of Port Pateson.

According to Luders, the crocodiles are found mainly in the Nagpen river and Red Water, which flow into Port Pateson, and the Alligator River, a short inlet to the north of Wonos Nawon (Figure 2). The condition of the Nagpen river apparently deteriorated after Cyclone Wendy, and perhaps became unsuitable for crocodiles. In the early 1980s, crocodiles were believed to occur mainly in the Alligator River.

Neither Dickinson nor Luders reported any attacks by the crocodiles on humans, and apparently such incidents had never occurred up to the early 1980s. They did, however, record a number of attacks on crocodiles by humans: six animals were shot by a local resident prior to 1972, including one of about 5 metres; seven crocodiles were shot by Solomon Islanders in 1973; a 4.8-metre crocodile shot in 1980; and occasional, undated, spearings by villagers. Although there were no reports of attacks on humans by Dickinson and Luders, they did report that crocodiles fed on cattle, pigs and dogs.

Figure 1: The Pacific location and the major islands of Vanuatu, showing those (●) from which crocodiles have been recorded.

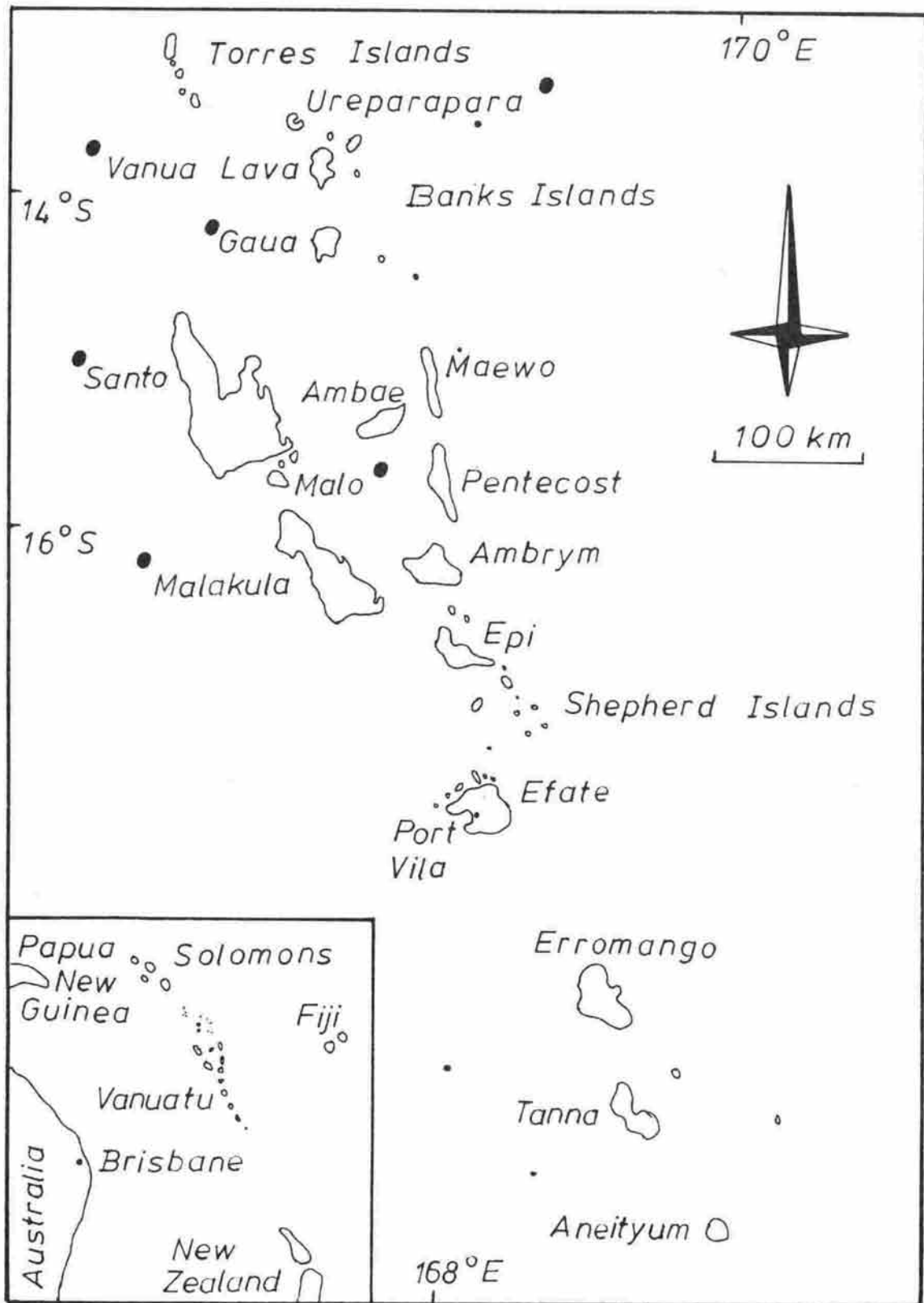
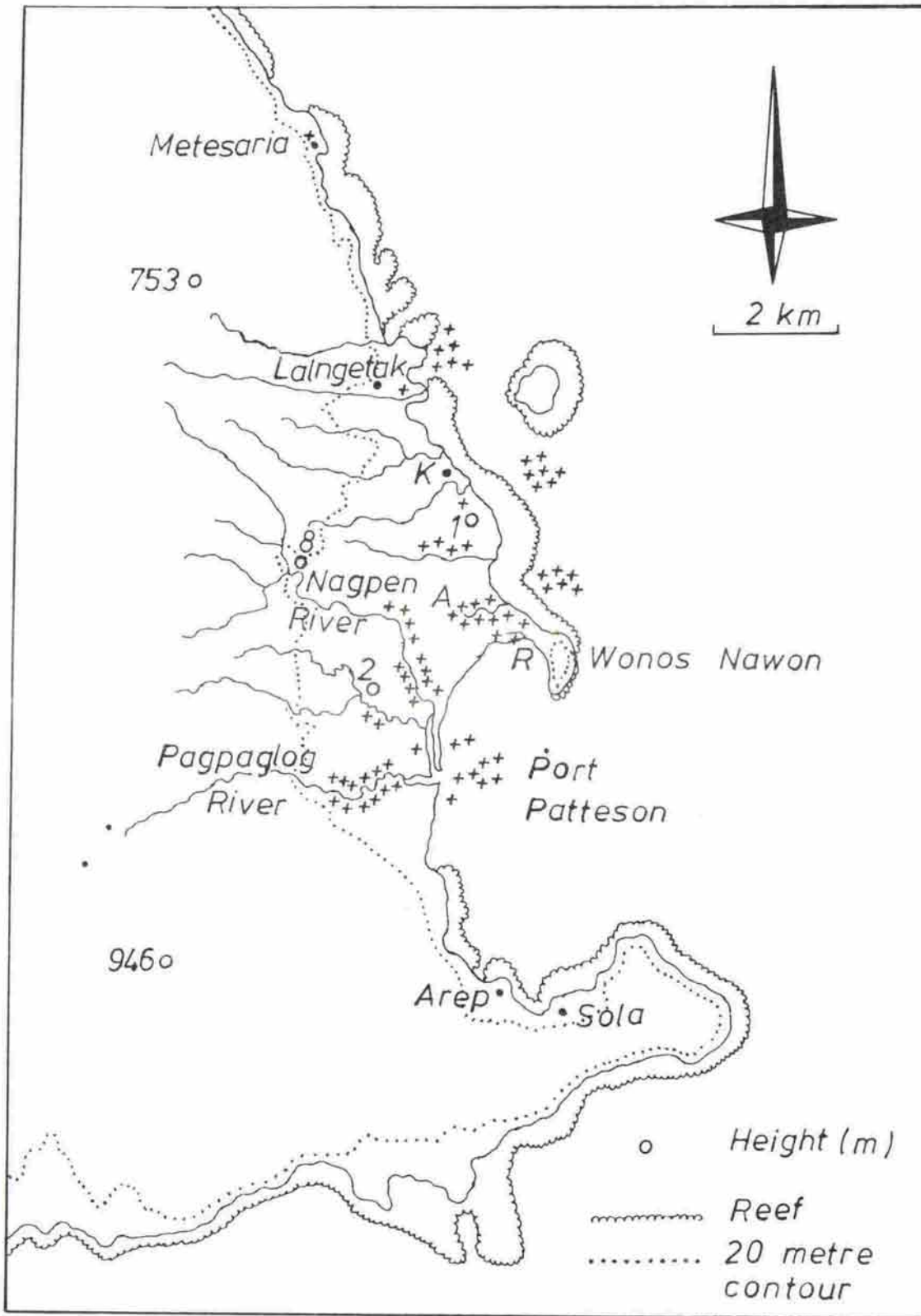


Figure 2: Reported locations (+) of crocodile sightings on east coast Vanua Lava
 (K=Kwanglav, A = Alligator River, and R = Red Water)



Thus, following Cyclone Wendy in 1972, the status of the crocodile in Vanua Lava is uncertain. However, six "small" crocodiles (apparently less than two metres) and a larger one (three metres) were reported by villagers in late 1982 or early 1983. As Dickinson did not visit Vanua Lava but Luders spent two weeks there, the report of Luders is probably more reliable.

It appears, then, that at least seven crocodiles were present in the early 1980s. As eight crocodiles were reportedly shot between 1973 and 1980, it appears either that at least 15 animals survived the cyclone or an unknown number survived and there was some breeding occurring. The latter seems likely, as evidenced by the reported occurrence of the six "small" crocodiles swimming together in the early 1980s. Normally, such grouping behaviour persists only for about eight months after hatching and territorial behaviour begins at the age of about 2.5 years (IUCN, 1982).

2. Aims and Objectives of the Survey

2.1 Aims

The crocodile is an animal of some interest worldwide and the status of the Vanuatu population is uncertain. Thus, the Environment Unit of the Ministry of Lands, Minerals, Geology and Rural Water Supply undertook a short project in June 1989 to evaluate the present status of the estuarine crocodile in Vanua Lava, the only island in the country where it is known to have bred.

2.2 Objectives

The objectives of the project were to:

- assess the current status of the estuarine crocodile in Vanua Lava;
- attempt to find explanations for whatever the current status is;
- assess interactions between humans and crocodiles;
- assess the condition of the crocodile's known main habitats; and,
- make any recommendations deemed necessary concerning the crocodile in Vanuatu.

3. Methods

The study was carried out by three main methods during field trip to Vanua Lava from 13-17 June 1989:

- a. Visits to the main areas from which the crocodile has been reported (Alligator and Nagpen rivers, Red Water), both to look for crocodiles and to assess the habitat;
- b. Discussions with villagers to gain information on their recent and past experiences and knowledge of the crocodile; and,
- c. Distribution of a questionnaire, designed to supplement b. and gain information from more villagers than we could talk to (Annex 1). Twenty questionnaires were completed and returned to us.

As the results obtained from these three different methods complement one another, the data gained from each are considered jointly in the following account.

4. Results

4.1 Arrival of Crocodiles in Vanua Lava

Dickinson (1981) reports that according to tradition, all the Vanua Lava crocodiles were descended from one colonizing female. Luders (1983) mentions that he discovered no stories or beliefs about the crocodile and assumed that if such ever existed, they had been forgotten with time. However, practically every person we talked to or who filled in the questionnaire recounted the same story - that the crocodile was accidentally introduced to Vanua Lava by John Coleridge Patteson, the Anglican Bishop of Melanesia from 1861 to 1871.

The reported details of how exactly Bishop Patteson was responsible for introducing the crocodile vary somewhat. Thus, the following were reported: one crocodile jumped out of his hands; one crocodile escaped from his ship anchored in the bay; the Bishop let two crocodiles he had have a swim in Red Water and they escaped; the Bishop let two crocodiles have a swim in the sea, and lost them; the Bishop brought ashore two small crocodiles in a dish and placed there close to Red Water, after which they subsequently escaped. Thus, all these stories are essentially the same, but it is strange that they were not recounted to Luders during his investigations on the island.

If the story is true, exactly why the Bishop would have crocodiles on his boat is a mystery. He certainly would have plenty of opportunity to get them, for they are common in some parts of Solomon Islands to the north of Vanua Lava. The Bishop made annual tours around the Solomons and northern Vanuatu, first from his base in New Zealand and then later from Norfolk Island.

Six biographies of Bishop Patteson (Armstrong, 1900; Fox, 1953; Gulch, 1971; Halcombe, 1872 and 1873; Page, 189?) were studied in an endeavour to cast some light on this mystery. However, there is no mention of crocodiles in any of them, either in the Solomon Islands, Vanua Lava or on the boat.

Some biographies quote extensively from the bishop's personal letters. He was an accurate and meticulously detailed recorder of what he saw. Perhaps an examination of his letters would reveal a reference to crocodiles. Until an examination is completed, confirmation of the Bishop's purported introduction of crocodiles to Vanuatu cannot be made.

Although Patteson was Bishop of Melanesia from 1861 to 1871, he visited Vanua Lava for the first time in 1856. Apparently on that occasion he visited the west side of the island, and his first visit to Port Patteson (named by him after his father) was not until 1857. Thus the introduction would have been between 1857 and 1871. If the crocodile was introduced this way, it was obviously fortuitous. If only one crocodile was introduced, it must have been a pregnant female. This would mean it was at least 2.2 metres long (about 1.5 feet), and a highly dangerous animal. If two small animals were introduced, they must have been a male and a female and lucky to survive to maturity, a period of perhaps 15 years in the case of a small male.

If the crocodiles were not introduced by Bishop Patteson, then the most likely explanation is that the island was colonized by one or more animals coming down from Solomon Islands. Crocodiles are common at Vanikoro, one of the most southerly of Solomon Islands, and the distance from Vanua Lava, about 150 kilometres, could easily be traversed by them.

4.2 Present Numbers of Crocodiles in Vanua Lava

Out of 18 replies on the questionnaire, 14 people estimated the crocodile population at 1-10 animals, three people at from 11-20 and one at more than 60. Two of these people stated specifically that there was one only, whilst one person said there were three. In discussions with villagers who seemed knowledgeable about the crocodile, there was consensus that there are only two or three presently living on the island.

The best available evidence then suggests that there are very few crocodiles remaining, quite possibly only two or three. These were stated to be large animals. All respondents except one said they had never seen young animals at all, whilst one said he had not seen them for "a long time". It thus appears that the crocodiles, however many there are, are not breeding and have not done so for some time.

Luders' observation that small crocodiles were seen in 1982 or 1983 is strong evidence that they were breeding at least up until the early ISSOs. If indeed there are only two or three animals left, then there is a good chance that they are of the same sex a 50:50 chance if two remain, and a 1 in 4 chance if three remain.

In response to the question asking whether crocodile numbers were increasing, steady or declining, the answers were nine, seven and three respectively. The number of people stating increases is somewhat confusing, as all other evidence points to very low numbers. Perhaps this reflects an incorrect assumption made, in fact that recently the crocodiles have been attacking people, something they had never previously been known to do (Section 4.6). Those people reporting a decline stated that it had occurred since cyclone Wendy. Those people reporting no change gave no indication of the time scale to which they were referring. In the last five or six years numbers appear to have been consistently low.

All people that we spoke to said that crocodile sightings are now extremely rare. Additionally, tracks in sandy or muddy areas are also infrequently seen. As many of the people spoken to live within only a few hundred metres of the crocodile areas and frequently visit these rivers and mangroves, such sparse sightings must be considered reliable. It is in direct contrast to the situation prevailing prior to 1972, when crocodile sightings were a daily occurrence.

During our visit, we spent many hours in known crocodile areas and along the sandy shores where sightings were once commonplace. We saw no crocodiles nor any signs of them.

4.3 Distribution of Crocodiles

The known localities of crocodile sightings, compiled from the present study, are shown in Figure 2. These results show that crocodiles were mainly distributed along the rivers and streams and offshore areas of the low-lying eastern coastal regions of the island, from the Pagpaglog river to Lalnegetak.

They extend somewhat the localities recorded by Luders and show that they were well established along the Pagpaglog, Nagpen, Red Water and Alligator rivers as well as the area north of the latter up to Lalnegetak. In total, the low-lying lands of this area occupy about 17 km² and represent the probable maximum size of the locality commonly frequented by the crocodile.

Elsewhere in Vanua Lava, crocodiles have been reported from Metesaria (this study) and the Tes river on the northwest of the island by Luders.

On the other islands of Vanuatu (apart from Santo, Malakula and Malo mentioned earlier) crocodiles have been reported (this study) from Gaua (25 kilometres to the south) and Lorup Bay (Ureparapara island) 25 kilometres to the northwest of Vanua Lava. In both these instances, local villagers speared a crocodile to death. At Ureparapara, this spearing took place shortly after cyclone Wendy, suggesting that the animal had been washed away from Vanua Lava.

4.4 Breeding Crocodiles

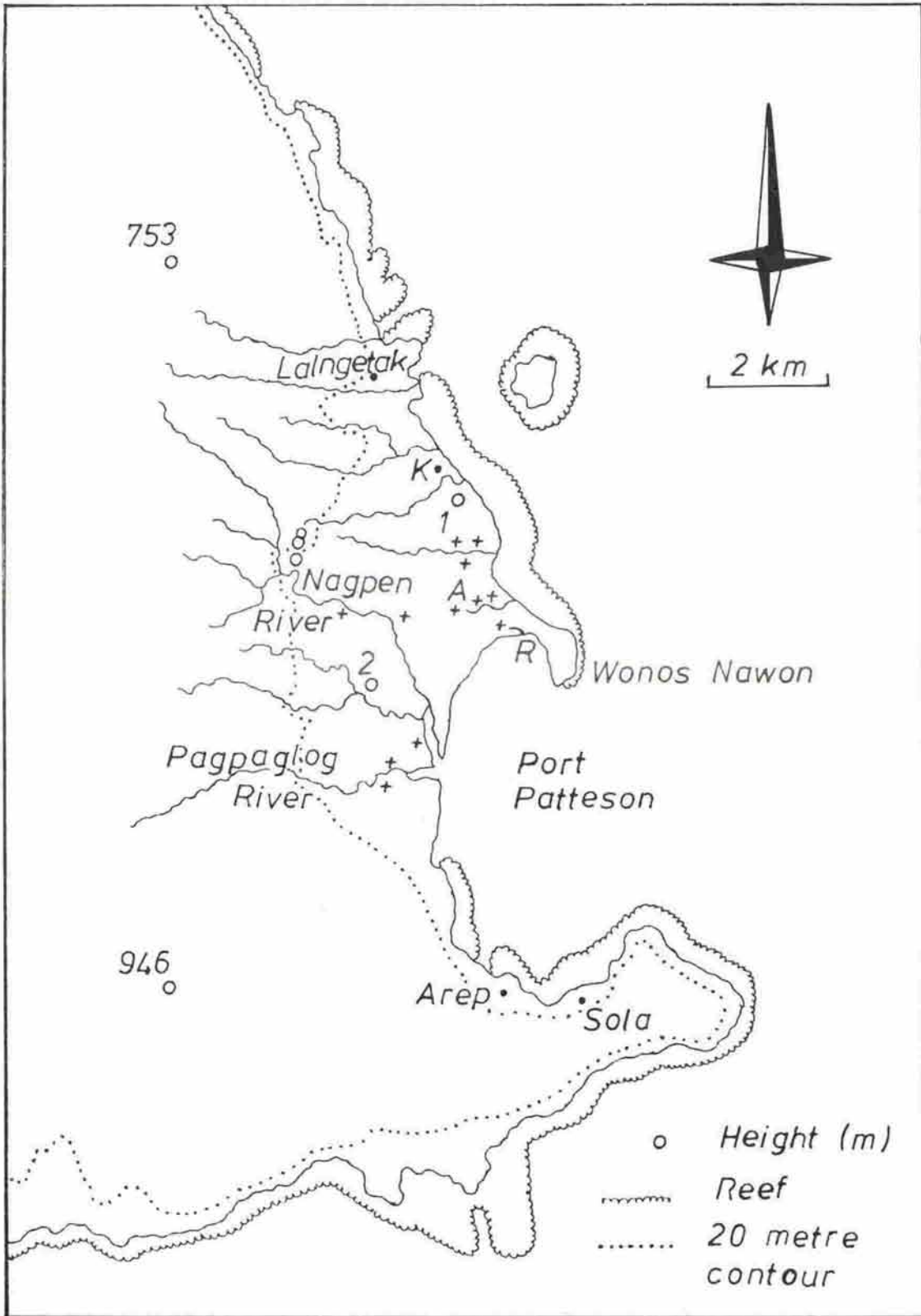
The reported localities of crocodile nesting areas are shown in Figure 3. Generally they are from the same areas as reported for crocodile sightings (Figure 2). Thus nesting sites were reported along the Pagpaglog, Nagpen, Red Water and Alligator rivers as well as on the unnamed stream to the north of the latter. Sites were reported up to three or four kilometres inland. No nesting sites were reported from the northern part of the area in which crocodiles are/were regularly seen.

There is no doubt that a crocodile breeding population of the crocodile was well established prior to 1972. Since cyclone Wendy, the situation is not so clear, but breeding does appear to have occurred at least sporadically until the early 1980s. Since 1982 or 1983 when young crocodiles were seen, it is possible that little or no breeding has occurred. The absence of any sightings of young animals in the last few years suggests strongly that breeding has either not occurred during this time, or has been unsuccessful. If the latter, eggs must presumably not have hatched as young animals would almost certainly have been seen.

4.5 Crocodile Habitats

The area between the Pagpaglog river and Lalnegetak, the main crocodile habitat, is unusual for Vanuatu. It is an extensive and recent (geologically) alluvial terrace, formed from accumulated sediments brought down from the mountains of many traversing rivers. It has a maximum altitude of about two metres, less near the coast. The coastal areas are liable to inundation by the sea (Quantin, 1977).

Figure 3: Report localities (+) of crocodile nesting sites on east coast of Vanua Lava (K = Kwanglav, A = Alligator Rive, R = Red River)



The vegetation forms several zones from the coast to the higher ground several kilometres inland (Quantin, 1977). Along the coast of Port Patteson is a narrow strip of littoral forest, dominated by the screw palm (*Pandanus*) and tamanu (*Calophyllum inophyllum*).

Behind this, particularly to the north of Wonos Nawon, is a belt of mangroves, dominated by *Rhizophora* and *Avicennia*. This extends for about 700 metres inland along the Alligator River. Behind the mangroves and north of the Nagpen river, is a belt of swamp forest and swamp grassland, behind which is an area of dense burao (*Hibiscus tiliaceus*) forest with many open grassland clearings. South of the Nagpen river, the vegetation is a complex of coconut plantations and swamp grasslands, with riverine forest along the lower Pagpaglog river, which also has a narrow belt of mangroves at its mouth.

During our field trip to Vanua Lava, we were able to make some detailed observations of the Nagpen, Alligator and Red Water rivers. The Alligator River is in fact a tidal inlet through the mangrove forest which meanders for about 500-700 metres from the sea before coming to an abrupt halt against a short, steep bank behind which is terrestrial vegetation. Freshwater trickles down this bank, and there is no river as such draining the hinterland. The mangrove forest around the Alligator River is a mature stand, with the canopy at about 1520 metres. The river is generally about 10 metres wide, but up to about 50 metres at the mouth, with a few short side channels. The river water was strongly brackish, turbid and somewhat dark brown, due to humic staining from the freshwater inflow.

The Nagpen river is very different. The water is strongly bitter to the taste and doubtless highly acid. The river drains an extensive sulphur springs area in the hinterland, and this must be the source of the acidity.

The water is a dark, peaty brown, clear except for some lower stretches which have a yellowish / brownish suspension in them. This latter may be due to some chemical precipitation taking place as the fresh and salt waters mix near the river mouth. The river appeared to be nearly sterile. No fish were seen and very little invertebrate fauna could be found - only a few insect larvae and what looked like snail trails in the coarse sand sediments of the lower reaches of the river.

There were, however, quite a large number of waterstriders (Gerridae) alongside the banks. No aquatic plants were seen. The vegetation along the lower reaches of the river was dominated by the screw palm (*Pandanus*) and tamanu (*Calophyllum*). Burao also occurred here and became progressively more common until several hundred metres from the mouth it was the dominant vegetation for the next three kilometres.

Along the lower tidal reaches of the river, the lower parts of the *Pandanus* stems and of the one mangrove tree seen were stained an orange colour, presumably from sulphur precipitated out of the river water. Yellow sulphur deposits were also seen on stones in shallow rapids further up the river. Several people also reported that the crocodile reputed to inhabit the river is also stained yellow from the sulphur.

The mouth of the Nagpen river has shifted in recent years. On the topographic map of Vanua Lava it is shown as having a separate mouth from the Pagpaglog river, about one kilometre to the north of the latter. At the time of our visit however, this mouth was closed off by a steep sand bank. At the point where the river used to enter the sea, it now turns abruptly south and runs parallel to the shore for about one kilometre before flowing into the sea through a shared mouth with the Pagpaglog river.

The Red Water is a 10-12 metre wide channel which meanders for about 200-250 metres parallel to the shore. It then narrows to two or three metres before disappearing into a swampy impenetrable forest. The channel is slow flowing and choked with dead trees, perhaps debris from past cyclones. The banks are lined mainly with *Pandanus* trees, whilst the water is a clear, dark, peaty brown colour.

There is little doubt that this extensive coastal plain would provide a good habitat for crocodiles. It is a complex of rivers, wide and slow-flowing at least in their lower reaches and tidal mangrove creeks backed by dense, virtually impenetrable swamp grasslands / forests and burao forests. Along the coast of Port Patteson is a wide shore with sand banks at the mouth of the Pagpaglog and Nagpen rivers, where crocodiles used to be seen frequently basking in the sun.

North of Wonos Nawon and up to Kwanglav is a shallow, sheltered lagoon behind the fringing reef, up to 600 metres wide. This makes it one of the wider lagoons in the country. Several people reported that young crocodiles used to be frequently seen in this lagoon, feeding in its shallow waters. Thus whatever the cause of the crocodile decline, it does not appear to be due to a lack of suitable habitat or its destruction by cyclones.

4.6 Crocodile Relations with Man

In reply to question 10 of the questionnaire, 15 people did not like having crocodiles on the island, one didn't care and three people liked them. The latter thought that a protected area should be set up for the crocodiles or that crocodile farming should be attempted, as in Papua New Guinea. Everyone we talked to did not like the presence of crocodiles. So crocodiles are not popular on the island, at least with people living near them.

The reasons for this unpopularity is due to attacks on people and predation of domestic animals by crocodiles. Part of the story associated with the introduction of crocodiles by Bishop Patteson is that, after realising he had unwittingly introduced them to the island, he cursed them and forbade them to attack humans. They could eat cattle, pigs and dogs and anything else they could find.

Up until about two years ago, for whatever reason, the crocodiles do not appear to have attacked anyone, at least there are no records or stories of such events. In 1987, however two attacks were reported. In one instance, a crocodile tried to sweep a man off the narrow (15 cm) log bridge laid across the Alligator River. Even at low tide this log is under water, and at high tide the water is chest high.

Fortunately, the crocodile missed and the man escaped. In the second report for the year, two boys were attacked as they swam in the shallow lagoon off the mouth of the Alligator River. Again, the crocodile swept at the boys with its tail, but missed and swam away.

Two more attacks were reported in 1988. In the first instance, two men were attacked, again off the mouth of the Alligator River. The men saw the crocodile coming towards them and managed to climb a tree in time. Apparently the crocodile jumped up to try and catch them, but failed and swam away.

In the most serious incident, a youth was attacked as he walked across the log bridge of the Alligator River. Apparently he saw it

coming, removed his shirt and flapped it at the crocodile, attempting to frighten it off. This failed, however, as the crocodile leaped up, grabbed his arm, and pulled him into the river. It then swam with him to the mouth of the river. The youth fought the animal and escaped after the crocodile stored him for dead amongst some mangrove roots. He was severely bitten and scratched around his body, legs and arms and took nearly five months in hospital to recover. This incident was widely reported throughout the country.

With these recent attacks, particularly where the victim was lucky to escape with his life, it is not surprising that crocodiles are unwanted on Vanua Lava. The only path along the east side of the island is through tile mangrove swamps and across the creek of the Alligator River. The path is in regular use, and users do so with much trepidation and anxiety.

The human population of the area is small. In Kwanglav district north of the crocodile area, the population in the 1979 census was 49. In Solo area, south of Port Patteson, it was 56. The population around Kwanglav has probably not changed much since 1979, but it has markedly increased around Solo. This is due mainly to the building of a secondary school at Arep, with several hundred pupils and staff, and the establishment of a local government head-quarters at Solo.

A Christian Training Centre was also recently completed at Wonos Nawon, and a church centre is being built nearby. There are 3040 people at these institutes, all living within a few kilometres of the main crocodile area. However, most have no reason to visit or traverse the Alligator River mangrove swamp where all the attacks on humans have occurred. The maximum number of people living near the crocodiles (between 200m and 3 km) is about 100, at Wonos Nawon and around Kwanglav.

The crocodiles are regular predators of cattle and dogs, with most people reporting attacks. They also said that wild pigs and turtles were killed. Horses and goats were not reported as being attacked, there being none in the area.

Apparently attacks on humans have only started in the last two years. When crocodile numbers were high, before 1972, there were no attacks and crocodiles and humans apparently lived in mutual disinterest with each other. Why they should attack people now is unknown. Perhaps, the few remaining crocodiles are old and find it easier to attack people than cattle, pigs, turtles and dogs.

5. Discussion

There seems to be no doubt that prior to cyclone Wendy in 1972 there was a breeding population of the estuarine crocodile in Vanua Lava. There were daily sightings and animals of all sizes were present. The population was centred around the rivers that flow into Port Patteson and north of Wonos Nawon up to the Lalnegetak area. The size of the population is not known but estimates ranged from several dozen up to 200. The crocodiles had never been known to attack anyone up until 1987.

It is also clear that cyclone Wendy destroyed a large proportion of the crocodile population. How many survived is not known, but in view of the fact that seven crocodiles were apparently shot in 1973, it would seem that at least a dozen did so. It also appears, assuming that the 1982/83 sighting of a group of small crocodiles was correct, that breeding was occurring.

Since about this time, there are no reports of villagers seeing young animals, and it may be that the remnant population is no longer breeding. If this was so, the most likely explanation is that the two or three crocodiles reputed to be remaining are of the same sex. If this is the case, then unless one or more crocodiles of the opposite sex are introduced, then in the course of time the population will become extinct. This would then mean a shrinkage of the total range of the estuarine crocodile as Vanuatu is the most easterly point of its distribution. A shrinkage of the total range has already occurred, as crocodiles are no longer found on the west coast of the Indian sub-continent or the coast of China.

The most likely contributing cause of the crocodile decline in Vanuatu is cyclones. The existing habitat, some 17 km², appears to be perfectly good for them. The shooting of seven crocodiles shortly after cyclone Wendy probably removed a large proportion of those surviving at that point. Since cyclone Wendy, Vanua Lava has been struck again full force on three occasions by cyclones Gordon, Hind and Anne in 1979, 1985 and 1988 respectively. Given the undoubted ability of cyclones to kill crocodiles, any or all of the three most recent cyclones may have removed further animals. With the already small number of animals surviving 1972, the killing of any further individuals, from whatever cause, would be a serious impediment to their long term survival.

During our visit to Vanua Lava, the villagers overwhelmingly gave the opinion that they did not like having the crocodiles on their island. In view of the recent crocodile attacks, this is not surprising. Present indications are that the remaining crocodiles will die out naturally within a few years. Till then it is hoped there will be no more attacks. The villagers are afraid of them and if they possessed rifles or shotguns, would attempt to shoot them.

The crocodiles in Vanua Lava appear to be on the verge of extinction. With no further breeding, this will happen. So the question is whether or not attempts should be made to establish a breeding population on the island. This could best be done by introducing a number of sexually mature animals on the island, or by releasing a larger number of immature animals and allowing them to reach maturity on the island. The latter is technically easier, but more risky given that they may die naturally or otherwise before they reach maturity.

As the crocodiles are so unpopular on the island, and have never been nor are likely to be of any economic value, there is no local justification for attempting to build up a breeding stock. The only reasons for this would be if it was in the national or international interest to have a breeding population here. Nationally, Vanuatu is more interesting because of its crocodiles. Everyone knows of them. Vanuatu also has a somewhat small number of vertebrate species, thus the loss of one of them would impoverish the natural fauna even further.

However, we do not feel these national considerations should override the wishes of the local people on Vanua Lava. This could also be said of the international interest, where any loss of a crocodile population is undesirable, and particularly as it would be the loss of a nation's entire stock and a shrinkage of the overall range of the species. This loss would not, however, threaten the overall survival of the estuarine crocodile. This will be decided in countries, such as Australia and Papua New Guinea, where large numbers of crocodiles occur.

So in Vanuatu, we do not recommend any action be taken to protect the remaining crocodiles. If this means that they will eventually die out, then so be it. The temporary occupation of Vanuatu by crocodiles would then have been but a fleeting occurrence, an event common enough in the colonisation of small islands by species of many types.

6. Acknowledgments, Literature Cited and Outputs

6.1 Acknowledgements

We are grateful to the South Pacific Regional Environment Programme for providing funds for this project. We appreciate very much the assistance and hospitality of Father Lake Mini during our stay at Port Patteson, and the help from villagers and government officers in answering our questions. We also thank the Vanuatu Meteorological Service for providing information about the occurrence of cyclones at Vanua Lava.

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6.3 Outputs

In addition to the present paper, a shorter more popularly -styled paper entitled "A Survey of the Estuarine Crocodiles (*Crocodylus porosus*) of Vanua Lava" has been submitted to *Naika*, the Journal of the Vanuatu Natural Science Society.

It is also proposed to submit a short technical paper to an international scientific journal such as *Biological Conservation*.

7. Problems and Environmental Significance and Implications

7.1 Problems Encountered

None, apart from the lack of crocodiles.

7.2 Environmental Significance and Implications

7.2.1 Local

The project has confirmed many of the previous findings concerning the estuarine crocodile and increased the recorded knowledge of them in Vanuatu. Every indication is that there are very few crocodiles on Vanua Lava, and these do not appear to be breeding. It thus seems only a matter of time before they become extinct on the island, and therefore Vanuatu. This loss would be generally welcomed on Vanua Lava, although it would result in an impoverishment of the already low numbers of vertebrate species in Vanuatu.

7.2.2 Sub-regional and regional

The estuarine crocodile occurs in Vanuatu, Solomons, Palau, Australia and Papua New Guinea. In Palau it was reported to be relatively common in the late 1970s, and 300 were killed in a control programme in 1975. Its present status is unknown. In the Solomons it has declined in the last 40 years, chiefly due to hide-hunting. It is thought to be uncommon on most islands except Vanikoro, where it is regarded as sacred.

In Papua New Guinea it is widespread, though hunted everywhere, mainly in populated areas. It is farmed in some areas, young wild animals being caught and reared in cages. In Australia, numbers declined following hunting after World War II. It is now protected and numbers seem secure providing this protection can be maintained.

Thus the crocodile populations in the island nations of Vanuatu, Solomon Islands and Palau are probably at risk of extinction (with the possible exception of Vanikoro) in the short to medium term. The populations of Australia and Papua New Guinea seem to be secure in the long-term, although populations may become locally extinct in Papua New Guinea. Undoubtedly, the Vanuatu population is the one most at risk in the region.

7.2.3 Global

Globally, the Vanuatu estuarine crocodiles are the most easterly. Thus, the loss of the population here would cause an overall shrinkage of the range of this species. This would be regrettable, but the fate of the population here will not have any effect on the global survival or extinction of the species. This ultimate fate will be decided in countries where it is now abundant, such as Australia and Papua New Guinea.

7.2.4 Management and Policy

The Vanuatu crocodile population can probably only be saved from extinction by importing and releasing adult and/or young animals from elsewhere. This would be difficult and expensive. It would also be unpopular and resisted by the residents of Vanua Lava. In view of all this, the best policy seems to be to not interfere in any way, and let nature take its course. Time will tell what that course will be - either extinction or, least likely, a recommencement of breeding.

8. Recommendations for Follow-up and Further Work

8.1 Work in Vanuatu

The status of the crocodile in Vanua Lava should be checked every two or three years. This could be done quite simply by a short visit to the island to hold discussions with the local villagers. They would be able to report on the frequency and nature of any sightings. From these the status of the crocodiles on the island could be deduced.

8.2 Overseas Work

There is a need to evaluate the status of the estuarine crocodile in Solomon Islands and Palau. This can be done fairly simply and inexpensively by a combination of site visits and questionnaires, as in the current Vanuatu project. The populations in Australia and Papua New Guinea are already the subjects of much study in those countries.

