

The Management of Crocodiles in Papua New Guinea

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TWO species of crocodylian occur in Papua New Guinea, the endemic New Guinea freshwater crocodile, *Crocodylus novaeguineae* (in both Papua New Guinea and Irian Jaya), and the more widely distributed saltwater or estuarine crocodile, *Crocodylus porosus*. Relative to many of the world's crocodylians, both exist in large numbers in the wild, and both are exploited heavily for skins under a management programme developed over the last sixteen years.

However, in the late 1960's it appeared that the crocodile skin industry would collapse unless regulatory controls were introduced. Trade in skins greater than 20" (51 cm) belly-width was banned, to protect breeding stock, and moves were set in place to shift the emphasis of the harvest from direct hunting for skins to a ranching operation. Later, a ban on trade in small skins was introduced to prevent the wasteful killing of small stock, which represents an economic loss to the country as a whole.

The development of the ranching operation was supported by the Government of Papua New Guinea and the United Nations. Village farms and a live crocodile purchase network were established that could move stock through collecting farms to large-scale commercial rearing farms. The development of ranching has been slower than predicted, but has contributed significantly to a 43% increase in production between 1976 and 1984, despite a slow decline in the total crop. Early results from a monitoring programme suggest the wild population is increasing, even though 14,000-35,000 *C. novaeguineae* and 3200-7300 *C. porosus* skins are exported annually (1976-1983).

Largely because of the skin industry, crocodiles represent a very significant, tangible resource in Papua New Guinea, at both local and national levels. Their continued conservation under a pragmatic management programme tailored to the needs of a developing nation, can be approached with optimism. The development of that programme and its results are described in this chapter.

DISTRIBUTION AND STATUS CLASSIFICATIONS

Papua New Guinea consists of the eastern half of the island of New Guinea and many small neighbouring islands; it lies between 2 and 12 degrees south of the equator, between Indonesia and Australia. New Guinea is a rugged island with high mountains, extensive fresh and saltwater swamps, and as a result of high rainfall, large rivers and numerous lakes.

Crocodylus porosus is classified as "endangered" by the International Union for the Conservation of Nature and Natural Resources (IUCN) (Groombridge 1982), and is on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). When it was transferred from Appendix II to Appendix I, in 1979, the population in Papua New Guinea was retained on Appendix II, to allow a controlled export trade. Papua New Guinea still had a sizable population and a management programme which would enhance the long-term conservation of the species.

Crocodylus novaeguineae occurs in large numbers in Papua New Guinea, despite heavy exploitation throughout the island. It is classified as "vulnerable" by the IUCN (Groombridge 1982) and is listed on Appendix II of CITES.

Within Papua New Guinea, *C. novaeguineae* is found throughout the lowland areas of the mainland, but does not occur on the islands. The southern and northern populations (Fig. 1) differ in some life history traits, and may eventually prove to be taxonomically distinct. Although occasionally found in river estuaries, *C. novaeguineae* is more common in the heavily vegetated swamps associated with many of the rivers. In contrast, *C. porosus* seems to prefer more open water — rivers and larger lakes — although it occupies overgrown, vegetated channels that may be more than 1 km from such open waters (Cox 1985). There is considerable overlap in the distribution of the two species (Fig. 1) and they are frequently found in the same lake. Any ecological

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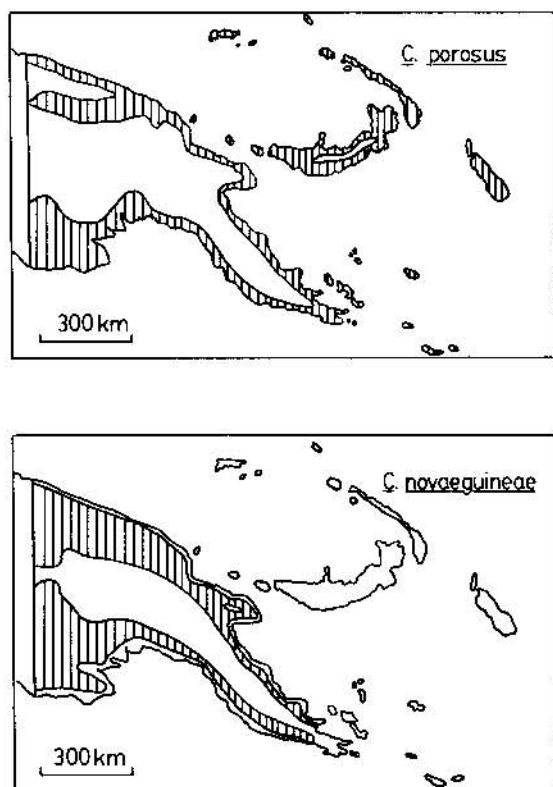


Fig. 1. The distribution of *Crocodylus porosus* and *Crocodylus novaeguineae* within Papua New Guinea.

separation, by factors such as diet, is unknown. The relative scarcity of *C. porosus* in river estuaries, which is often considered their "classic" habitat, may be due to previous heavy exploitation and a difficulty in recolonising because of easy hunting and increased human activity in most estuaries.

ECOLOGY AND POPULATION DYNAMICS

Information on *C. porosus* and *C. novaeguineae* nesting in Papua New Guinea comes mainly from Hall (1983), Cox (1985) and Hollands (unpublished observations). Both species build near identical mound-type nests, in similar vegetation types, although there are interspecific differences in clutch and egg sizes, and intraspecific differences between the northern and southern populations of *C. novaeguineae*.

In the Sepik area, in the north of Papua New Guinea, *C. porosus* nesting peaks in the wet season, although some individuals nest all year round with the exception of the two driest months. Mean clutch size is 59.2 eggs (range 25-79). Of these, 9% can be expected to be infertile, and of the remainder, 32% to be taken by predators (almost exclusively people), 20% to be lost to flooding, leaving about 48% of fertile eggs to hatch.

No data are available on hatchling or juvenile mortality of *C. porosus* in Papua New Guinea, but if the levels that do exist are similar to those in Australia

(Webb *et al.* 1977, 1984; Messel *et al.* 1981, 1984), 40-50% mortality in the first year and approximately 20-30% per annum for at least the next few years is to be expected. *C. porosus* is a fast-growing crocodylian, with females reaching sexual maturity in about 10 years (about 2.4 m total length; 23-24" belly-width).

The northern population of *C. novaeguineae* nest during a relatively short period, in the dry season, with hatching occurring as water levels increase. Mean clutch size is 35.3 eggs (range 17-51), and of these, 11% can be expected to be infertile. Of the remainder, 22% can be expected to be taken by predators (almost exclusively people), 15% to be lost to flooding, leaving about 57% to hatch.

In contrast, southern *C. novaeguineae* nest mainly in the wet season. In the drier parts of the south nesting occurs at the start of the wet season (Bolton 1981a; Hollands and Cox, unpublished data), and in heavier rainfall areas such as Lake Murray, nesting peaks in the middle of the wet season (Hall 1983; Hollands and Cox, unpublished data), but occurs during 10 months of the year. Mean clutch size in the south is only 21.7 eggs (range 8-36; 35.3 eggs in the north), although eggs from southern nests are bigger than those from northern nests (Hall 1983; Cox 1985). The reasons for this variation are unknown.

It has been suggested that the high juvenile mortality in *C. porosus* is partly due to cannibalism (Messel *et al.* 1981) and partly due to social interactions. If so, survivorship among the less "aggressive" *C. novaeguineae*, particularly in heavily vegetated swamps, may be greater than generally appears the case with *C. porosus*.

Crocodylus novaeguineae is a slower growing animal (Bolton 1981a; Hollands, unpublished data) than *C. porosus*, it breeds at a much smaller size (particularly the southern population), and probably reaches maturity at a younger age. It would seem likely that, as with *C. porosus*, middle-aged females would be the most productive breeders, with larger eggs and larger hatchlings.

HISTORICAL PERSPECTIVE

Although a clear picture of the 'pristine' crocodile population would be a valuable reference point to have, no surveys appear to have been conducted prior to the period of heavy hunting. Comparisons of past and present densities could still be confounded by the effects of "wariness", selected for over thirty years of hunting — seeing more crocodiles before the period of hunting would not necessarily prove there were more.

Anecdotes from early explorers do not generally indicate numbers much greater than at present, but some reports are confusing. For instance Hurley

(1924) describes the flora and fauna he saw on a 250 mile journey up the Fly River to Lake Murray. But he does not mention seeing *any* crocodiles. On Lake Murray he indicates good numbers of crocodiles: "the tepid waters are infested with great crocodiles which constantly swam about the ship at a safe distance and returned to mudbanks well out of range".

Crocodylus porosus is currently very rare on the lake, although *C. novaeguineae* is still common in heavily vegetated coves (but is rarely seen). However, mudbanks are not present on the lake either. Hurley could have been referring to observations made on the Fly River, even though the extract is taken from his description of Lake Murray.

From the accounts of the D'Albertis, Wilcox and Hargreaves' expedition to the Fly River in 1876 (Goode 1977), it seems crocodiles were scarcely encountered, although D'Albertis does comment that the natives were afraid to swim in the river because of crocodiles. Similarly in a report on the trip of the "S. S. Bonito" up the Fly and Strickland Rivers in 1885, Everill (1886) states that they saw no "four-footed creatures" at all, but saw the tracks of pigs and "many tracks of Alligators". It is normal now to see a number of *C. porosus* when travelling this stretch of river.

Hunters and village elders seem to agree that crocodiles were more numerous in the past than they are at present, particularly in the open rivers and estuaries, where *C. porosus* would have taken the initial brunt of skin-hunting. A low level of exploitation of crocodiles for meat in Papua New Guinea (Allen 1977) has existed for a long time, but it is unlikely that any serious impact on the populations occurred before commercial hunting for skins started.

Data on the value of "Hides and Skins" exported from the northern (New Guinea) and southern (Papua) regions between 1930 and 1967, which are believed to be mainly crocodile skins, are summarised in Table 1. The first commercial exports, worth a few hundred kinas a year, occurred during the early 1930's and then the trade was temporarily halted. It resumed again in a more serious manner in 1950 in Papua, with commercial hunting spreading across to the New Guinea region in 1953-1954.

To extrapolate these and later data to numbers of skins, details are needed on skin prices, the size distribution of skins, their species and grade. Patchy information on these is available (for example Table 2), but a considerable amount of projection is still needed to estimate numbers; notwithstanding that export values may have been deliberately understated by exporters (Heron 1970). In compiling the estimates on Table 1, data on the numbers were available for the period 1969-84 and on the numbers and species composition from 1973-74. For other

years numbers were estimated from export values on the basis of the following assumptions: exports were composed of 80% *C. novaeguineae* and 20% *C. porosus*; prices could be adequately estimated by extrapolating from a regression line relating price to year for the period 1958-73 (obtained from various price lists); and, that a correction for average size of skin could be made on years where numbers of skins and export value were both available. On average, *C. porosus* skins brought 1.5 times as much as equivalent sized and graded *C. novaeguineae* skins.

Commercial hunting expanded rapidly in the early 1950's and peaked during the 1960's, with nearly 350,000 skins exported between 1961 and 1966. This crop could not be sustained and problems became evident during the late 1960's. The number of skins and value of exports dropped sharply, and even though the price of skins on the world market remained constant, the average value of each exported skin dropped by more than 50%, reflecting a substantial drop in the average size of skins (the early hunting selectively removed the larger size classes). This drop could also indicate a scarcity of the more valuable *C. porosus* and increased hunting of the less valuable *C. novaeguineae*; unfortunately there are few data on the species composition within exports during the 1960's.

After the *Crocodile Trade Ordinance* of 1966 was introduced (1969), the decline in numbers was arrested and a new, lower level established. This was probably due to both the limited protection given to breeding stock and to the replacement of expatriate hunters, using rifles, with local hunters using mainly spears. The number of skin exported never returned to the high levels of the 1960's, but the value of the industry has been increasing steadily as a result of improved skin prices and a steady increase in the average size and quality of skins exported (see later; Figs 8 and 9).

MANAGEMENT LEGISLATION

Concern about the possible collapse of crocodile populations in the 1960's came from conservationists, the industry and politicians (Heron 1970). Commercial exploitation had only been occurring for some twenty years, yet already its importance in low-lying rural areas was established. Crocodiles are frequently the only significant form of cash income for whole districts.

The Government of Papua New Guinea took an enlightened view for the time. They recognised that an industry based on wildlife exploitation need not be detrimental to the wild populations, and if properly managed could assist the long-term conservation of wildlife. The crocodile industry was examined thoroughly, and four important areas of concern were identified:

Table 1. The value, in Papua New Guinean kinas (k), and numbers of crocodile skins exported from Papua New Guinea. Data for 1930-67 are "Skin and Hide" exports, believed to have been mainly crocodile skins. "-" signifies no data are available; numbers prior to 1969 have been estimated from values and information on skin prices. Prior to 1975, 1 kina = AUS\$1.00.

Year	Papua (k)	New Guinea (k)	Total Value (k)	C.n.	Number of Skins C.p.	Totals
1928-29	0	-	-	-	-	-
1929-30	0	-	-	-	-	-
1930-31	4502	-	4502	-	-	-
1931-32	128	-	128	-	-	-
1932-33	32	-	32	-	-	-
1933-34	130	182	312	-	-	-
1934-35	176	0	176	-	-	-
1935-36	170	0	170	-	-	-
1936-37	202	0	202	-	-	-
1937-38	-	0	-	-	-	-
1938-39	-	0	-	-	-	-
1939-40	-	0	-	-	-	-
1945-46	0	0	0	-	-	-
1946-47	0	0	0	-	-	-
1947-48	2	6	8	-	-	6
1948-49	0	100	100	-	-	80
1949-50	0	46	46	-	-	36
1950-51	12,880	18	12,898	-	-	7950
1951-52	22,546	0	22,546	-	-	11,900
1952-53	27,646	112	27,758	-	-	12,500
1953-54	46,076	31,068	77,144	-	-	31,100
1954-55	44,272	54,394	98,666	-	-	34,900
1955-56	47,582	60,184	107,766	-	-	34,900
1956-57	53,137	74,006	127,143	-	-	37,400
1957-58	71,128	68,234	139,362	-	-	37,700
1958-59	30,690	55,460	86,150	-	-	17,700
1959-60	42,790	87,040	129,830	-	-	21,700
1960-61	103,154	153,160	256,314	-	-	35,410
1961-62	259,384	247,214	506,598	-	-	59,000
1962-63	315,058	373,606	688,664	-	-	74,300
1963-64	506,074	376,828	882,902	-	-	75,300
1964-65	391,614	463,804	855,418	-	-	59,200
1965-66	-	-	1,001,075	-	-	70,000
1966-67	344,472	392,480	736,952	-	-	53,100
1967-68	-	-	508,700	-	-	36,600
1968-69	-	-	472,800	-	-	26,500
1969-70	-	-	452,000	-	-	34,146
1970-71	-	-	264,000	-	-	24,429
1971-72	-	-	198,000	-	-	23,367
1972-73	-	-	173,000	-	-	25,937
1973	-	-	421,000	51,439	11,453	62,892
1974	-	-	473,000	62,948	7272	70,220
1975	-	-	258,000	17,690	6974	24,664
1976	-	-	588,000	23,379	6257	29,636
1977	-	-	813,000	26,571	6618	33,189
1978	-	-	1,625,000	30,886	7157	38,043
1979	-	-	1,665,000	35,474	7626	43,100
1980	-	-	1,335,000	27,709	5797	33,506
1981	-	-	1,320,241	15,021	4281	19,302
1982	-	-	2,340,898	24,733	4853	29,586
1983	-	-	870,236	15,111	3456	18,567
1984	-	-	2,294,389	21,268	5145	26,413

1. *Over-exploitation.* In the late 1960's the crocodile resource was being heavily over-exploited. The number of skins exported each year had dropped, the average size of skin exported was very small and, crocodiles were becoming harder to find. Some people in the industry believed that the resource had been devastated and would be unable to recover (Heron 1970).

2. *Biologically inefficient harvesting.* Hunters preferred to kill large crocodiles, but would kill any, which meant that the demographically

valuable breeding stock, which would take years to replace, had and was continuing to take the brunt of the cropping. The increasing numbers of small crocodiles taken was indicating that large crocodiles were becoming scarce.

3. *Economics.* The resource owner gained a small percentage of the revenue derived from skins. Most went to expatriates who either employed the landowners as assistants or hunters, or gave a poor exchange of trade goods for the valuable skins.

Table 2. The export price (in Papua New Guinea kinas) paid per inch (2.54 cm) of belly skin for Grade 1 raw crocodile skins leaving Papua New Guinea during the period 1957-1984.

Year	<i>C. novaeguineae</i>	<i>C. porosus</i>
1957-58	0.43	—
1961-62	1.00	1.50
1962-63	1.08	1.62
1963-64	1.40	2.09
1964-65	1.64	2.70
1967-68	1.50	2.90
1968-69	2.10	3.05
1972-73	2.10	3.10
1973	2.10	3.10
1977	6.00	7.20
1978	7.43	8.60
1979	6.11	7.80
1980	6.14	8.07
1981	7.06	8.39
1982	7.85	9.34
1984	8.50	11.00

4. *Poor international marketing.* Most skins were sent to Singapore, which was a trading house rather than a final user. The trade names for *C. novaeguineae* and *C. porosus* — “Singapore large scale” and “Singapore small scale” respectively — have stuck from this period. The very significant price increase between Singapore and the tanneries in Europe was not being obtained by Papua New Guinea.

These problems, it was reasoned, could be overcome by legislation and direct Government involvement in the industry.

A Private Member's Bill, the *Crocodile Trade Ordinance* of 1966, came into effect in January 1969, and it was later expanded to the *Crocodile Trade (Protection) Act*. This Act provided a legislative base for a controlled industry by establishing the following:

1. Hunting crocodiles became a restricted activity which could only be carried out by landowners, or with their direct permission;
2. A system of licences was introduced for anyone trading in crocodile skins. This gave the Government control over operators, and by tight residency requirements, increased local participation in the trade (a licence to trade was specific to one local council area, although a number of licences could be issued in any one area). Crocodile traders sold skins to separately licenced, export companies;
3. All exports of skins had to be documented and approved by the Management Authority of the Papua New Guinean Government;
4. To give partial protection to breeding stock, a maximum size limit was imposed on tradeable skins. This did not affect landowners' traditional rights to hunt and kill crocodiles above that size, but prohibited the killing of such crocodiles for

commercial gain. The maximum size limit was set at 20" (51 cm) of commercial belly-width, which corresponds to about a 6' (2 m) crocodile; it is now known that *C. novaeguineae*, particularly the southern population, breeds when considerably smaller than this (Hollands 1982a), however such data were unavailable in 1969;

5. Legislative powers for setting quotas, closed seasons or even imposing a total ban were obtained, although they have not yet needed to be used;
6. The killing of very small crocodiles, with belly-skin widths of less than 7" (18 cm), was prohibited by regulation, taking effect in 1981. The intention was that these crocodiles should be caught alive for ranching, or simply left to grow to be killed later, when their skins were much more valuable. The killing and export of small crocodiles represented a wasteful loss at both local and national levels.

The *Crocodile Trade (Protection) Act* made no provisions for protecting areas of habitat, but a more general conservation Act, the *Fauna Protection Act* was introduced in 1966 and with amendments, led to the current *Fauna Protection and Control Act* 1976. This Act covers the establishment of a range of protected areas with particular emphasis on “grass-roots” conservation, and the establishment of wildlife management areas, with rules drawn up by local committees. The hunting and utilization of many species was restricted to their being taken by traditional means for traditional uses.

Papua New Guinea was an early signatory to the CITES convention and it was ratified as part of Papua New Guinea's laws by the *International Trade (Fauna and Flora) Act*, which came into force in 1981. This Act brought the documentation and reporting of international trade in crocodile products into line with other countries.

DIRECT GOVERNMENT INVOLVEMENT IN THE INDUSTRY

Skin Marketing Service

In 1976 the Wildlife Division of Papua New Guinea established a Crocodile Skin Marketing Service, which involved Government directly in the business side of the skin industry. The aims were to assist resource owners and improve international marketing (Laufa 1982), with the following terms of reference:

1. To investigate markets other than Singapore;
2. To establish contacts with tanneries and importers in Europe and Japan;
3. To promote crocodile skins from Papua New Guinea by improving the quality of skins offered for sale;

4. To monitor international market prices for skins from Papua New Guinea;
5. To investigate methods of shipment, especially by air;
6. To standardize the grading of skins and investigate methods of curing and their effects on tanned leather; and,
7. To stimulate competition, maintain price stability of skins, and ensure a fair distribution of income to people in rural areas.

The Skin Marketing Service concentrated on buying skins in the more remote parts of the country, where fewer private buyers operated. Skins were also purchased on Government stations by wildlife and agricultural extension officers. Most skins were sent by air to Port Moresby, with freight paid at the receiving end. The Skin Marketing Service handled up to 20% of exported skins, and its work, particularly in linking exporters in Papua New Guinea with the tanneries in France and Japan, proved to be of immense benefit to the industry.

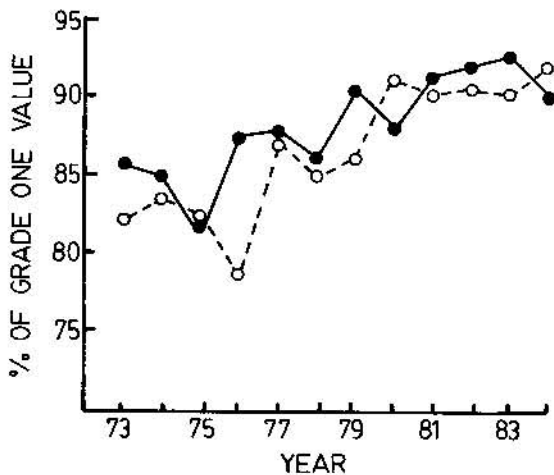


Fig. 2. The increase in "quality" of *Crocodylus porosus* (solid line) and *Crocodylus novaeguineae* (dashed line) skins exported from Papua New Guinea as indicated by the percentage of the maximum value (if all were Grade 1 skins) actually obtained.

A publicity campaign on correct skinning techniques and hide preservation, along with the introduction of the preservative "merpine", resulted in a steady increase in the quality of skins exported (Fig. 2). By 1982 it was considered that the Skin Marketing Service had successfully achieved its stated objectives (Laufa 1982), and in line with Government policy to promote the private sector, it was discontinued. In some parts of the country Provincial Governments took over the function, as they felt the existence of a Government buying service would keep prices competitive.

Improving the Efficiency of Exploitation

Although little was known about the breeding biology and population dynamics of crocodiles in Papua New Guinea, it was assumed they would be relatively prolific egg producers, and as such, hatching mortality could be expected to be high. Accordingly, the wild populations could be expected to sustain a crop of very young crocodiles better than a crop of older ones. As the skins of small crocodiles are worth very little, to either the hunters or to Papua New Guinea as a nation, it was decided to harvest them alive and raise them on farms until they were at a marketable size. With the objective of passing the benefits of management to the resource owners, it was decided that the village hunters should do the raising ("ranching" in terms of CITES), although this would clearly involve a considerable commitment to extension work.

In 1965, Wildlife Division established a research-demonstration Crocodile Farm at Lake Murray, in the Western Province. A considerable interest in the project was shown by hunters in the surrounding area, who started copying pens and keeping stock even before the government started to encourage moves in that direction (Puffett 1972). The Government established additional demonstration farms in the major crocodile producing areas.

Courses were held at these farms and they were used as extension bases. Crocodile farming became an important part of the syllabus in agricultural colleges, and in-service courses were held for extension officers. Crocodile farming became popular at the village level and by 1976 there were 7000 crocodiles on village farms (Bolton 1981b). It became apparent that Government had neither the manpower nor funds to fully pursue the shift to village ranching, and the United Nations (UN) was approached for assistance. This resulted in a United Nations Development Project (UNDP) under the auspices of the Food and Agricultural Organisation (FAO), entitled: "Assistance to the Crocodile Skin Industry in Papua New Guinea".

This project provided UN staff and volunteers, with a total project funding of US\$1.7 million between 1977 and 1983. The objectives were to continue the extension work promoting village farms, provide technical advice for the establishment of large scale crocodile farms, and to establish a system for supplying stock to these larger farms. Simultaneously the Government of Papua New Guinea gave financial assistance to potential village crocodile farmers through subsidised equipment and government guaranteed loans. A "National Policy on Crocodile Management" was taken, which had the following aims:

1. To replace indiscriminate hunting for skins by the harvesting of very young crocodiles for raising to commercial size;

Hunting is seasonal in its intensity, with most occurring during the dry-season. As large areas of seasonal swamp recede, and river levels drop, crocodiles concentrate in the permanent water bodies making them easier to detect. Spotlight surveys indicate observed densities in any one stretch of water during the dry season can be up to twenty times the density in the same stretch of water during the wet season.

Many people who hunt crocodiles have no other major source of monetary income, but they will normally be members of a family who are primarily subsistence hunter-gatherers or farmers. They are thus not dependent on crocodiles for essentials throughout the year and will hunt when they feel it is worthwhile. There are strong correlations between skin prices, the number of skins from wild-killed animals on the market, and season.

Some areas have large crocodile populations but do not have a major trade in crocodile skins. The human population density may be too low, development may not yet be capable of supporting a skin buying network, or the swamps may simply be too inaccessible, even for local inhabitants.

Crocodile traders will normally rescrrape and resalt skins before selling batches to an export company. One of the legal requirements for a licenced crocodile trader is that he makes a return detailing skins purchased in each quarter of the year. This is only enforced on companies and exporters, because many traders cannot write. The Crocodile Management Project issues free standard-format docket-books for all buyers to use, and one copy of each transaction is submitted to the Government at the end of the quarter, when it is entered onto the computers. Even if returns are only made by companies and exporters, this allows detailed records of the number, size and species of crocodiles being harvested in each area, throughout the year.

Ranching

Ranched skins are providing an increasing percentage of the total exports of crocodile skins from Papua New Guinea (Figs 3 and 4). Ranching itself has been evolving from a village level industry to one based on larger commercial farms, and there are now various pathways through which an individual crocodile can be moved prior to export (Fig. 6).

Crocodiles are normally caught by torchlight at night from dugout canoes, and the catching is frequently done by women and children whilst the men hunt for larger animals. The crocodiles will either be kept in a simple pen in the village (Fig. 7) or taken to the nearest trader who has facilities (and a licence) for buying and keeping live crocodiles.

A number of the major crocodile producing areas have farms that will purchase live crocodiles and act as collection centres. Once 300-400 small crocodiles

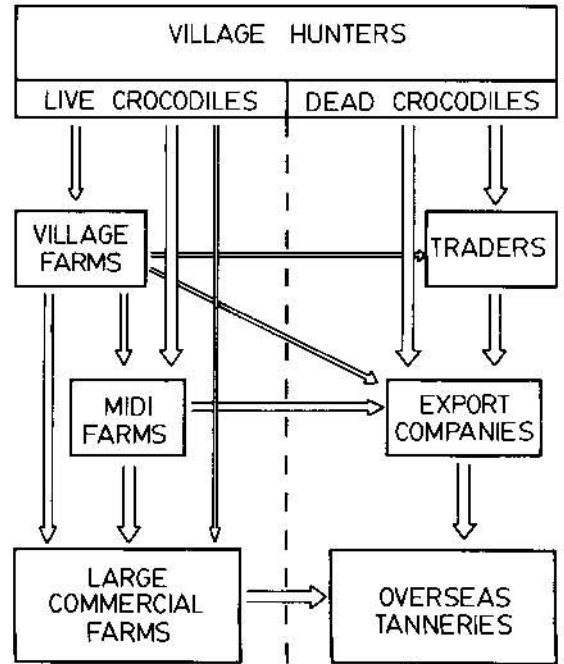


Fig. 6. The various routes through which crocodiles taken by village hunters eventually reach overseas tanneries. The thickest arrows indicate the most common routes.

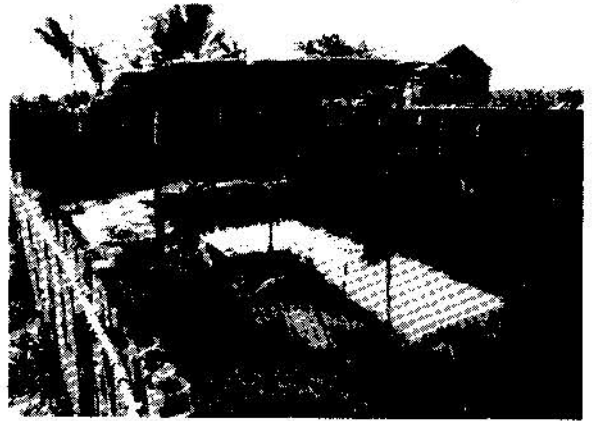


Fig. 7. A village crocodile pen in Papua New Guinea.

have been acquired, one of the commercial farms charters a light aircraft to fly in and collect them. Air transport of small crocodiles, in specially designed cardboard boxes, results in very low mortalities. Normally crocodiles less than 1 m long will be collected as the freight costs for large animals are prohibitive. Some of the collecting farms or "mid-ranches" receive all their revenue from selling live crocodiles, but most also rear a percentage to culling size themselves. Virtually all of these farms can buy far more than they could hope to feed, and so the surplus gives them a rapid financial turnover while providing stock for the larger commercial rearing farms.

The two major commercial rearing farms have about 16,000 crocodiles at present. They utilize the waste from large scale poultry operations for food,

which gives slower growth rates than meat or fish (Bolton 1981a; Hollands, unpublished data), but which is available in large quantities at a suitable price. Pen design and management is quite different on the two main farms but neither have high mortalities nor significant disease problems and growth rates are economically acceptable.

Government policy has now allowed the large scale farms to establish a breeding programme for *C. porosus*, although it is unlikely that they will become "closed" self-sufficient farms. It is a means through which numbers of the rarer and more valuable *C. porosus* skins can be increased, and perhaps a means through which selective breeding can take advantage of the vast individual differences in crocodilian growth rates (Bolton 1981a; Hutton 1984). Increased experience with egg incubation and the care of hatchlings may also permit reduction of the age at which wild stock can be harvested for the farms.

An experimental *C. porosus* egg harvest has been carried out. Nests selected for harvesting were those considered likely to flood or to be taken by hunters for food. Results to date seem encouraging with excellent hatching success and reasonably low post-hatching mortality. As only about 50% of eggs hatch in the wild, and mortality between hatching and the normal size at which hunters kill crocodiles is probably significant, this approach could improve the efficiency of harvesting. It will depend on the economic viability and the degree to which an "alternative" harvesting strategy is socially acceptable to the hunters.

Export Procedures

There are ten licenced crocodile skin exporters in Papua New Guinea, and procedures are the same for wild and ranched skins. Fourteen days before the shipment date an application is lodged with the Management Authority which contains a full breakdown of the skins to be shipped along with the person to whom they are being shipped, and the date of shipment. The paperwork is checked, and if approved, is signed, stamped and sealed. A Government officer inspects the skins (to check sizes and details on the application form) and supervises the attachment of an individually numbered, non-usable, plastic security tag to each skin. On occasion tags are issued to exporters who attach them, but the skins are always made available for inspection.

Population Monitoring

Population monitoring was first seriously pursued in 1980, well after the ranching programme was initiated. It has been constrained by staff and funding shortages, but is considered a high priority by the Government and receives the majority of the Government funding for crocodile work.

In Papua New Guinea, the majority of crocodiles are in vast areas of heavily vegetated swamps. Floating mats or rafts of vegetation surround lakes, or totally cover them, with vegetation so dense that often no open water is visible. Such conditions significantly compound survey difficulties, which are already present from the increased "wariness" resulting from constant hunting.

A range of survey methods was tried and helicopter counts of nests (Graham 1980, 1981; Hollands 1984a) was considered the only practical method of quantifying population trends — the goal of the monitoring programme. Due to the fragmented nature of the nesting habitat, the lack of reliable habitat maps, and the lack of information on the percentage of the total number of nests that were actually visible from the air in different habitats, there was little utility in attempting to estimate the total number of nests in Papua New Guinea. Discrete survey sites and routes which gave an appropriate mix of habitats, hunting levels, and known densities were selected, and these have been surveyed annually or biannually (Hollands 1982b, 1984a). Surveys are now run twice a year, in March and October, just after the peak of nesting for each species. *Crocodylus novaeguineae* nesting is confined to a relatively narrow period in the northern area (Cox 1985), so virtually all nests have been made before the survey. With *C. porosus*, the March surveys coincide with the end of a definite peak in nesting.

Survey routes and results are plotted on large scale aerial photos, which greatly facilitates navigation in the complex swamp formations. Overlays, with habitat distributions along the survey routes, are then used to total the nest numbers in each habitat type. These are then compared within each habitat, on the basis of proportional changes from the previous year, to give a nesting index for each habitat. These habitat indices are then combined with appropriate weighting to give an overall annual index of nesting for each species in that area (Hollands 1984a).

In some areas, particularly in the more discrete river systems in the south-west of the country, repeat spotlight counts are conducted. However, for much of the country they are inappropriate as only a very small (less than 5%) proportion of the population is counted.

Analysis of export statistics and purchase dockets allows detailed monitoring of the crop taken each year. Although total numbers harvested depend on a number of factors, the extent and age structure of the crop are important additions to the survey data.

The results of the monitoring surveys and trade statistics analyses are regularly presented to the wildlife authorities, the Crocodile Advisory Board

within Papua New Guinea, the CITES Secretariat (Hollands and Wilmot 1985) and the IUCN Crocodile Specialist Group (Hollands 1982b, 1984a).

Biological research into various aspects of both wild and captive crocodiles is continually being pursued when resources allow it, however it is orientated at issues directly relevant to management.

THE EFFECTIVENESS OF MANAGEMENT

The effectiveness of the crocodile management programme must be judged within the socio-economic conditions in which the programme operates:

1. Virtually all land is held under customary land tenure, giving the landowner full control of that land; Government has no real say over what can and cannot be done with the land or the animals living on it. Land ownership is an issue which elicits strong feelings and Government frequently has difficulty in obtaining land even for projects such as hospitals and airstrips which would directly benefit the landowners.
 2. Papua New Guinea is composed of about half a million square kilometres, much of which is highly mountainous or swampy. The development of land transport routes is extremely expensive and as a consequence there is a very sparse transport system. Crocodile producing areas tend to have lower than average human population densities, they are not major centres for minerals or agricultural produce and, as a consequence, the road systems are least developed. For example some of the major rivers for crocodiles, the Strickland, Purari, Kikori, and the lower 500 km of the Fly, have *no* road access at all! By comparison, the Sepik is well off, with road access to three points along its 650 km length. Extension work depends heavily on air and water transport which is extremely expensive.
 3. There is a fragmented human population with well over 700 recognised languages among the population of three million.
 4. Papua New Guinea has made great progress in education in a surprisingly short period, but many of the decision makers at the village level, particularly in remote swamp areas, are elders who have frequently had little formal education.
 5. In many of these areas the people are primarily subsistence farmers or hunter-gatherers, frequently moving between different camps and villages. This conflicts with the sedentary existence needed for crocodile farming.
- Changes needed to optimise crocodile exploitation must by necessity be introduced slowly and cautiously. Government encourages management in the right direction, with improvements at every opportunity, but must be content with the relatively inefficient exploitation being sub-optimal rather than detrimental.

The Shift to Ranching

When the management programme to shift cropping from direct killing to ranching was first pursued, the economic aims were sound and the shift seemed to be achievable in practice. It had been demonstrated that crocodiles can live and grow under simple husbandry conditions, a pond surrounded by "bush material" posts and food in the form of local fish. It was considered feasible that farms could open in virtually all crocodile areas, and it was predicted that by 1980 there would be 100,000 captive crocodiles in the country, giving a yield of 30,000 skins per year (Downes 1978).

In practice, it proved impossible to live up to such high ideals, despite excellent work by UN staff, Government officers, and a massive campaign to promote the scheme. A number of major unforeseen problems were encountered with village rearing (Bolton 1981b; Rose 1982):

1. Crocodiles can only assimilate animal protein and need fairly large amounts of it; approximately 225 kg of fish to bring a yearling crocodile through to 18" belly-width (Bolton 1981a). Even with Government subsidised fishing nets, few areas could obtain sufficient protein throughout the year to meet the needs of both the human and captive crocodile populations.
2. In most lowland areas considered for crocodile farming there are large seasonal fluctuations in water level. Where pens were built well above high water level, water had to be carried to up to 2 km in the dry season. Even with pumps and pipes, which are expensive to buy and maintain in remote areas, the problem remained serious.
3. In many areas the restrictions of being tied to one camp for the whole year conflicted too strongly with traditional activities; pens were left unattended for fairly long time periods.
4. Despite initial enthusiasm, many village farmers began to lose interest when it became apparent that returns would only come after 2 or 3 years of hard work. As interest dropped the quality of husbandry dropped; escapes occurred, feeding was inadequate, and poor growth and high mortalities followed.
5. Government policy for village loans was for business groups not individuals. A few individuals within a group would work the farm, but all would expect an equal share of the profits. This led to disenchantment among those that had worked.

Although these problems affected many farms in one way or another, it certainly did not affect *all* of them. Some were run by people who provided a high level of management expertise and these have subsequently proved very successful. About 15% of village farms were considered as reasonably successful for more than one season (Bolton 1981b). Despite a high level of extension work and backup from both Government and the UN, 85% were unsuccessful. Village farming was probably "over-sold", and with the wisdom of hindsight, may have fared better had there been greater selection of groups prior to giving assistance.

It became obvious that the required level of extension work could not be maintained on a long-term basis, yet many village farms were not self-sustaining and needed regular assistance. It was decided to move the crocodiles to larger more sophisticated farms, which had an available food supply. Crocodile farming is theoretically possible at a low technology village level, but it can be done far more efficiently on a larger more sophisticated level of operation.

Approval for the change in emphasis from village rearing to large scale commercial ranching was granted, and approaches were made to potential suppliers of suitable waste food. A favourable response came from the management of Papua New Guinea's two main poultry operations, and both built crocodile farms with technical advice from the joint Government/FAO/UNDP project. A live purchase-distribution scheme for moving stock was then required, and Government demonstration farms became collection centres where hunters brought stock for sale. Additional purchases were made by Government officers whilst on extension patrols to village farms. Many of the village farmers took immediate advantage of the opportunity to sell stock and large numbers of crocodiles moved through the system in the first few years.

Live crocodiles purchased by the large-scale commercial ranches.

Year	<i>C. n.</i>	<i>C. p.</i>	Totals
1979	3958	974	4932
1980	7669	2141	9810
1981	8118	2178	10296
1982	8602	2799	11401
1983	2518	1901	4419
1984	>3000	>2000	>5000

These data do not include village farms for which no accurate records are available.

The system worked well, but was subsidised to around 40% of the value of exports (Hollands 1984b). In 1982 the FAO/UNDP project was close to termination and the Government crocodile project was being reduced. Demonstration farms were decentralised to Provincial Governments without

further subsidy. Their management did not have the background to suddenly transform a well-funded government project into a profitable private business, and most either closed or were reduced to buying for limited periods of the year.

The collapse of a key link in the stock supply network had a drastic effect on the large-scale ranches (see 1983 and 1984 above). Private companies tried to take over the role of the government demonstration farms, but the licencing legislation, really drafted to control the skin trade, limited a company to buying within one small area only. The Government farms did not have to comply with the regulations and conducted long buying patrols irrespective of council boundaries. One of the large-scale farms is now making efforts to set up a supply network and numbers are expected to return to the 1982 levels.

There are important lessons to be learnt from the experiences of Papua New Guinea. Programmes for the commercial exploitation of wildlife are usually drawn up by Government with advice coming primarily from wildlife biologists. Although this is an essential component of the expertise needed, few wildlife biologists appear to be competent economists. In the long-term, the success of crocodile farming and ranching ventures, and quite possibly many of the world's crocodilian conservation and management problems, will *not* be decided by answers to ecological questions, but rather by whether the management programmes are profitable or not.

HARVESTING EFFICIENCY

The early planners of the ranching programme predicted that the shift to ranching would not only increase the value of the harvest substantially (Downes 1971, 1978; Puffett 1972; Behler 1976), but as crocodiles would be harder to catch alive than to kill, it would probably reduce the total crop. Following on from this, the reduction in the average age of the crop would reduce the impact on the wild population, hence allowing a recovery to take place.

The shift to ranching is still incomplete, but it is possible to test these assumptions by comparing the total level of cropping with an index of production since the inception of the programme. This should allow trends in harvesting efficiency to be quantified.

One of the main intentions of the programme was to replace the export of small, virtually worthless, wild-killed skins with the sale of larger, ranched skins. Accordingly, neither the number nor the export value of skins alone (Table 1), is an adequate indicator of production; both the size (Figs 8 and 9) and quality of skins exported (Fig. 2) has changed significantly.

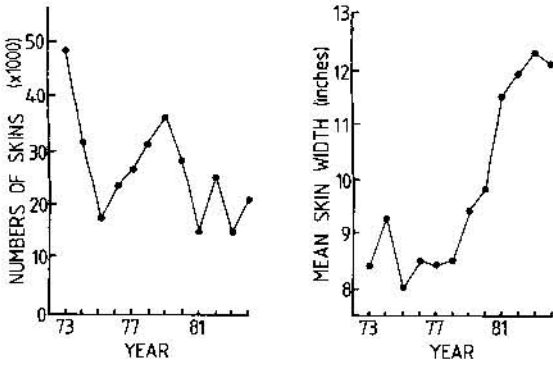


Fig. 8. Numbers (left) and mean belly-width (right) of *Crocodylus novaeguineae* skins exported from Papua New Guinea between 1973 and 1984.

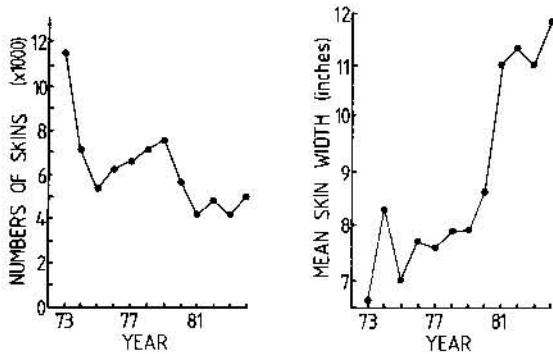


Fig. 9. Numbers (left) and mean belly-width (right) of *Crocodylus porosus* skins exported from Papua New Guinea between 1973 and 1984.

An index of annual crocodile skin production between 1976 and 1984 (Fig. 10) was derived by expressing all exports in terms of a standard unit — in this case, inches of grade 1 *C. novaeguineae* belly-skin, in the 7-9" (18-23 cm) range. Total inches of *Crocodylus porosus* skin was multiplied by 1.25, which approximates its value relative to *C. novaeguineae* skins; inches of small skins of both species (<7") were multiplied by 0.5, and large skins (10-20") by 1.5, which matches the scale of prices paid for different sized skins of both species. Grading was accounted for by multiplying by either 0.75 (grade 2), 0.5 (grade 3) or 0.25 (grade 4).

As factors such as the dry season water level and export price affects the size of the crop taken, an upward trend in production (Fig. 10) does not necessarily indicate increased harvesting efficiency. However, over the same period the total crop removed from the wild, as both skins and live stock for ranches, has been slowly dropping (Fig. 11). The export of small skins has been banned (and these are not yet going onto the ranches in equal numbers), so

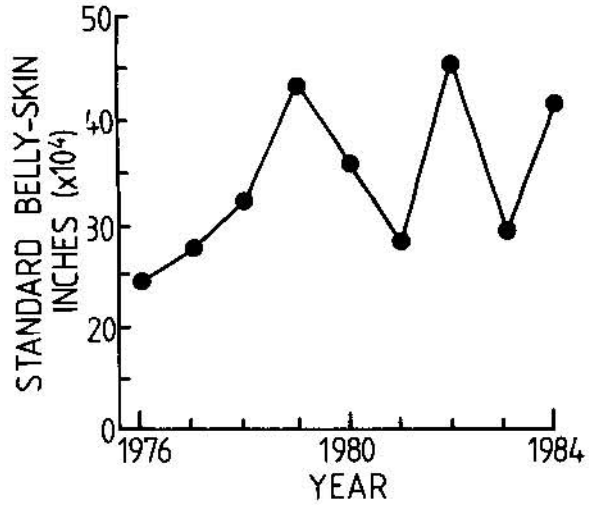


Fig. 10. Total Papua New Guinea crocodile skin exports between 1976 and 1984 expressed in terms of standard belly-skin inch equivalents (Grade 1, *Crocodylus novaeguineae*, 7-9" size bracket).

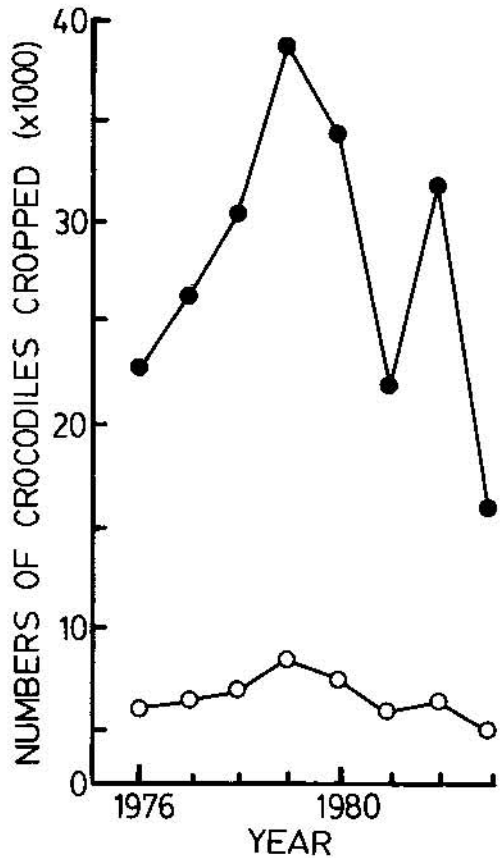


Fig. 11. The total numbers of *Crocodylus novaeguineae* (solid) and *Crocodylus porosus* (open) removed from the wild between 1976 and 1983 (includes skins and live animals going on to farms).

rather than the predicted decrease in the average size of crocodile cropped, there has been a slight increase.

These trends are summarised in Figure 12, which examines different production indices between 1976 and 1983, as a function of the 1976 values.

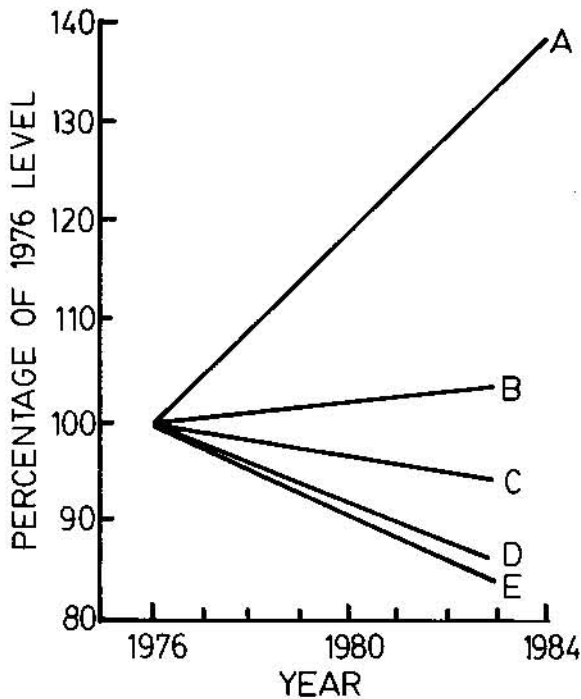


Fig. 12. Linear regressions relating different indices of skin production to the 1976 values (1976 to 1983-84): A, production in terms of standard belly-skin inch equivalents exported; B, belly inches of *Crocodylus novaeguineae* exported; C, belly inches of *Crocodylus porosus* exported; D, number of *C. novaeguineae* skins exported; E, number of *C. porosus* skins exported.

Clearly, production (A on Fig. 12) in terms of standardised inches of belly skin has been rising (43% between 1976 and 1983) while the other indices are either stable or declining.

Effects on the Wild Population

Results of the nest surveys (Fig. 13) are subject to a number of biases (e.g. percentage of females breeding each year) and thus great caution needs to be exercised when interpreting them over the short period that the monitoring programme has been operating. The results so far obtained show a very encouraging increase in the number of *C. porosus* nests — equivalent to a steady 15% annual increase. Numbers of *C. novaeguineae* nests have also increased, despite an apparent reduction in the numbers of females which nested in 1984.

In the two areas where spotlight counts have been conducted over a number of years, the results indicate a recovering population. In the delta area of the Gulf of Papua, the numbers of saltwater crocodiles were so low that the area was restocked with adults in 1980. Increasing numbers of hatchlings and yearlings are being recorded there annually. On the Bensbach River, which has been relatively lightly hunted for the last few years and seems to have limited nesting areas, the numbers of young crocodiles has remained fairly constant while numbers of larger ones have increased.

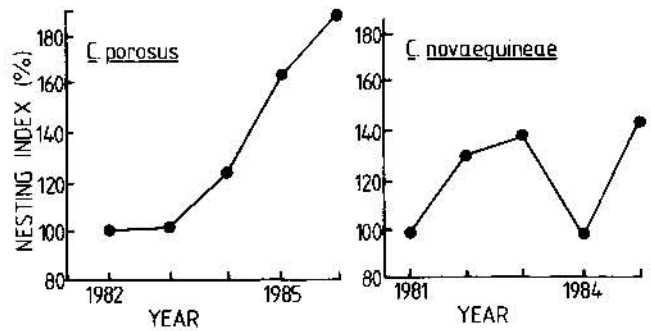


Fig. 13. An index of *Crocodylus porosus* and *Crocodylus novaeguineae* nest numbers between 1981 and 1985 in the Sepik River area of Papua New Guinea, expressed as a percentage of the 1981 value (see Hollands 1984a).

The trade statistics indicate the wild populations are slowly recovering. The mean size of wild skin between 1973 and 1984, shows a small but steady increase, rather than a decrease.

Because of its preference for the heavily vegetated, remote swamps throughout the country, *C. novaeguineae* in Papua New Guinea would be almost impossible to exterminate, even if no controls existed. However, great concern was felt for the *C. porosus* population, which was more vulnerable as a result of its greater value, larger size and preference for more open habitats. Up until 1980 the proportion of *C. porosus* in the national harvest (Table 1) was declining, either as a result of a still falling population, or a slower initial rate of recovery. The currently stable proportion of *C. porosus* skins in the total harvest, together with the trend towards increasing nest numbers do suggest that the management programmes are allowing more individuals to reach maturity.

PUBLIC ATTITUDE

Although most hunters express interest and concern about the long-term future of crocodiles, there is still a long way to go before this concern significantly alters hunting practices. The argument that appears to carry the most weight is still: "if all the crocodiles are killed off, what will your children be able to hunt?". The best argument for allowing a clutch of eggs to hatch, instead of being eaten, is how much the hunter will receive for the hatchlings.

This does not mean that hunters are unwilling to support the aims of the programme. They will and do support the aims, not because crocodiles are fascinating creatures, but rather because they are a valuable resource from which the community can benefit. As large scale exploitation of crocodiles for hides is relatively recent, traditional rules governing the exploitation have not developed. Without such rules, the short-term advantages of over-exploitation can outweigh increased benefits in the future.

However, most hunters appreciate that killing an oversized and therefore non-tradeable breeding female is not sound management; he could make more money by letting her breed every year and thus is likely to support the management "requests" to do so.

Direct agreement to support the management programme from local councils, rather than by relying on national legislation alone, is proving all important. "Rules" made by local councils are much more readily accepted, and prove easier to enforce, than those imposed from the "outside".

RESEARCH

When the current management programme was initiated, crocodiles in Papua New Guinea were very under-studied. *Crocodylus novaeguineae* was one of the least known animals of its size in the world, with only some preliminary observations at a 'natural history' level (Neill 1946) and a brief examination of anatomy (Mockton 1920; Schmidt 1928) in the published literature. *Crocodylus porosus* has received attention in other countries, but was unstudied in Papua New Guinea.

Early research concentrated on the practical aspects of crocodile ranching — diet, pen design, growth rates and related questions, which would show whether village farming was biologically feasible. As the scope of the ranching programme changed, research considered husbandry issues more appropriate to large-scale commercial farms — optimising growth rates, captive breeding, hatching care, transport of live crocodiles, and skin preservation. The findings of the research conducted on crocodile husbandry are reviewed and discussed by Bolton (1981a) and Rose (1982).

Although the management programme was based on cropping wild crocodiles, surprisingly little research was conducted on them in the early years. This omission caused concern to be voiced both nationally and internationally. With the arrival of the UN team, there was a substantial increase in research. However, as monitoring and research on wild crocodiles were not included in their brief (it remained the sole responsibility of the Government), research was mainly 'opportunistic' and conducted for interest when and where it could be included. It was therefore less productive than an integrated programme could have been. Much of this work concentrated on distribution and status (Whitaker 1979, 1980; Montague 1983) although some was on diet, injuries and parasites (Montague 1984; Ashford and Muller 1978; Ross 1977). Some surveys and farm research were also undertaken in co-operation with the University of Papua New Guinea (Pernetta and Burgin 1980), and visiting scientists worked on reproduction, behaviour and thermoregulation (Lang 1980, 1981).

A co-ordinated programme of research on wild crocodiles was initiated in 1979 with the arrival of an FAO ecologist and two volunteers with the specific brief to develop a population monitoring programme. As well as the population monitoring itself, which was described earlier, ecological research was undertaken on aspects of crocodile biology directly related to their efficient harvesting.

The major area of research was nesting biology of both species (Hall 1981, 1983; Cox 1985), as this was seen as an appropriate avenue for monitoring populations in swamp areas (Graham 1981; Hollands 1982b, 1984a). An understanding of egg mortalities was considered essential for assessing the optimum harvesting age, particularly in view of the extremely high egg mortalities reported for *C. porosus* in northern Australia (Webb *et al.* 1977). Research on nesting is continuing with more thought now on the problems of egg harvesting. A mark-recapture programme is also being conducted in a range of habitats, to give data on growth rates, movement and mortality in the wild. A far better understanding of population dynamics than we have at present will be needed before theoretical harvest quotas could ever be estimated.

Differences between the northern and southern populations of *C. novaeguineae* have been investigated from the points of view of cranial osteology, post-occipital scalation (Hall 1983; Ross 1984), reproductive biology (Hall 1983; Cox 1985) and size at maturity (Neill 1946; Cox 1985). Protein analyses are now underway to examine the degree of genetic separation between these populations, and between *C. porosus* populations in each region and on the islands.

Government considers management orientated research to have the highest priority for the limited funds available, and thus population trends and farm husbandry will remain the central targets. Unless funds and researchers from overseas take more advantage of Papua New Guinea's unique crocodile habitats, the wild crocodile populations are likely to hold important secrets for many years to come.

DISCUSSION

The crocodile management programme in Papua New Guinea is fulfilling its minimum objective — rural populations of people in crocodile areas have a stable industry based on crocodile resource that is no longer declining.

The partial shift to ranching has improved harvest efficiency, with a 43% increase in production from a reduced crop. This will presumably increase further as and if the shift continues to the limits of food availability. Previous experience suggests any encouragement to shift more rapidly would best be done by stimulating the commercial rearing sector

rather than by massive extension campaigns at the village level. If good profits are available, the companies will provide the input necessary to develop a supply network for moving live crocodiles from the swamps to the pens. Competition amongst farms, and between farms and the skin trade, will ensure that the prices paid to the resource owners are fair. The relatively large numbers of small stock needed will ensure landowners make good money by *keeping* breeding crocodiles on their land, providing a tangible incentive through which the long-term conservation of crocodiles can only gain.

Additional large-scale rearing farms are thus likely to enhance the "importance" of crocodiles, by providing even more competition. Two feasibility studies are now being undertaken by Government through a consultant, and these, with the extension of crocodile farming technology to industries which produce food suitable for crocodile rearing, provide perhaps the most cost-effective means for Government to stimulate the crocodile industry.

It was originally intended that the wild skin trade would be left to operate, within set size limits, until well developed rearing systems allowed landowners, in all parts of the country, to participate in them. It now seems certain that the wild skin trade in Papua New Guinea will continue indefinitely. The limiting factors are the amounts and costs of food, which currently dictate a maximum ranching capacity of about 75,000 crocodiles; this in turn gives an annual turn-off of about 20,000 skins, which is less than the number of wild skins exported. However, if a tuna cannery was established, as has been discussed for a number of years, the amount of food available could double.

The value of 20,000 large, good quality, ranched skins would be substantially more than that of 20,000 wild skins, so that it would seem economically sound to pursue that option. Furthermore, with developments in egg harvesting and the care and husbandry of hatchlings, increased ranching could direct the harvest at the demographically most inexpensive age classes — eggs and hatchlings. In the longer term, captive breeding may supply even more animals for ranching. However, even were ranching running at full capacity, there would still be a place for harvesting skins directly from the wild. Improvements here will come from optimising the size and quality of wild skins produced, and moves are already underway to either substantially reduce, by selective taxation, or ban the sale of the smallest size ranges of skins still permitted to be exported. As population data become clearer, it may also be desirable to reduce the upper size limit, to protect all adult females.

When the crocodile management programme was started many of the problems to overcome were biological ones; the whole concept of crocodile

ranching in Papua New Guinea was untested and the wild populations appeared to be in rapid decline. Today, there is still a vast amount not known about crocodiles, but we do know that ranching is successful and that the wild populations are at least stable. The problems on which the future of crocodile ranching, and hence our management programme, will rest are primarily economic ones. Large government subsidies are no longer provided to ranches and accordingly if they profit they will expand, if not, they must fold.

Crocodile ranching at a commercial level is an expensive undertaking, with an extremely large capital investment relative to the wild skin trade. Unlike some other countries, ranches in Papua New Guinea do not have the potential for tourist revenue and are therefore dependent solely on firm prices and a sympathetic operating environment. The world-wide tendency to apply onerous restrictions on such pioneering ventures with wildlife almost invariably results in poor Government-Industry relations, and is perhaps much more to blame for the failure of such enterprises than is normally recognised. This unnecessary phase was also encountered in Papua New Guinea, but today, excellent co-operation exists between Government and industry as they work towards a common goal — a sustainable harvest of crocodilians that ensures both a successful industry and the continued conservation of the animals.

The formation of a Crocodile Advisory Board has contributed greatly to this amicable relationship. The board consists of the country's Conservator of Fauna, the Secretary for Primary Industry, Provincial Government representatives from the major crocodile producing areas (on a rotational basis), and representatives from all sectors of the crocodile industry. The Board is empowered to make recommendations to the Government, but operates through the Minister for Primary Industry as the official Management Authority for crocodiles in the country. A new found cohesion within the industry has developed in what has traditionally been a "secretive" and fragmented industry. This co-operation within the country has improved our trading position overseas, and bodes well for the future.

Papua New Guinea has undoubtedly been "lucky" in its crocodile management programme. There are still vast areas of excellent crocodile habitat with low human population densities, and action was taken when there were still relatively large populations of both species in existence. It was able to "feel" its way into a new field without early mistakes being fatal, and with the knowledge that management could be inefficient without being detrimental.

Papua New Guinea may never have a management programme which is as biologically efficient nor as sophisticated as those being achieved in some

countries — nor would it necessarily gain by pursuing such goals. The current management programme is orientated directly at the people, and even though refinements and improvements will continue to “nudge” it in this or that direction, it is successful now. Despite being a new and relatively poor, developing country, Papua New Guinea has not only managed to take a dying industry and a rapidly declining crocodile resource, and turn both around, it has helped play a pioneering role in the development of crocodile management throughout the world. Papua New Guineans rightly feel proud of their achievements in crocodile conservation and management.

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