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EXCERPT

Wildlife Resources

A Global Account of Economic Use

With 21 Figures, 56 Photos and 56 Tables

403 pp.

Springer

PART II: UTILISATION OF SPECIFIC ANIMAL GROUPS

The principles of management and utilisation of wildlife resources, as described in Part I, are applicable to all wild animals. However, the importance of wildlife, both in a positive and negative sense, and consequently the scope of its management vary considerably between different animal orders, families or even species. This is mainly due to their zoogeographic and ecological distribution over distinct zones or areas in which climatic and socio-economic conditions differ greatly. Where animal taxa are distributed over several continents utilisation may vary accordingly between members of these. The local abundance of the wildlife resources, local traditions and utilisation, the level of cultural and technical development, and the marketability and demand for the particular products all determine which wild animals, for what purpose and in what ways they are utilised.

For the purpose of a global account of wildlife utilisation it is felt that a breakdown into zoological orders is most appropriate, although some of these are more important than others in the context of this book. Therefore, some chapters deal only with specific families or even sub-families of an order and others lump several orders together. Each "animal group" is taxonomically defined before its uses are described, and a table gives an overview of scientific names, geographical distribution and uses of the particular animal group. Taxonomic sequence and nomenclature follow the classification in GRZIMEK's Animal Life Encyclopaedia (Edition 1972-1984)[1].

In order to make reading easier each animal group is presented in a standard format which:

- firstly summarises the historical background of their use in different areas of the world;
- then describes present management and utilisation either more generally in terms of different production systems for the whole group or specifically for different species;
- assesses the economic importance and trends of the different uses;
- evaluates the implications of utilisation for the conservation of the animal group as a whole or of specific taxa;
- and lists cited literature references for further in-depth studies.

It is hoped that the reader will thus be able to consider and differentiate wildlife resources according to:

- employed types of utilisation, such as subsistence hunting, commercial hunting for meat, furs, or other products, ranching or farming, sports and trophy hunting, keeping and breeding in captivity, live sale;
- the products or services they render;
- and the socio-economic benefits derived from them by man.

The economic importance of the utilisation of the different animal groups may be expressed either for particular countries as a whole or in terms of the productivity and economics of local operations. For the reasons discussed in Chapt. 1.4 it is, however, extremely difficult to present comparative economic data even within one animal group as socio-economic, legislative and administrative conditions vary from country to country and obscure statistics. Therefore, in this respect the report can only give largely exemplary-type information.

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1) 13 vols.: Reptiles vol. 6, Birds vols. 7-9, Mammals vols, 10-13; Van Nostrand, London

2.1 UTILISATION OF REPTILES

2.1.1 TORTOISES AND TURTLES (*TESTUDINES*)

Of the order **Testudines** 5 families are of particular interest in the context of this book: the terrestrial True tortoises (**Testudinidae**), some Freshwater turtles (**Emydidae**), Sea turtles (**Cheloniidae**), the marine Leatherback turtles (**Dermochelyidae**) and some Side-necked turtles (**Pelomedusidae**); a few taxa of the Softshell turtles (**Trionychidae**) are also used for food or traded as pets. Whereas tortoises and Freshwater turtles comprise many different species in all warmer regions there are only seven species of Sea turtles and leatherbacks inhabiting most of the tropical seas. Tab. 5 shows that all tortoises and turtles are used for food; however, the shells, particularly of the Sea turtles, also serve various utility or ornamental purposes. Some of the smaller species are traded as pet animals and attempts are made to farm some of the Freshwater and Sea turtles.

General historical background

The only defences which tortoises and turtles have evolved against predation are their strong protective shell and their behaviour to withdraw into this, to dig into the earth or to escape and hide in the water. This was sufficient for them to survive all catastrophes and natural predators for more than 220 million years, but not the collecting man. In contrast to all other wildlife, no particular hunting or trapping effort is required by man to take these animals for food or other uses, and this fact has made this group of animals particularly vulnerable to more intensive forms of human exploitation. This applies to the tortoises on land, the terrapins and turtles in rivers and swamps, as well as to the large marine turtles: they have all constituted an easily accessible, favoured and much utilised resource since the earliest times. In most tropical countries the collection of tortoises is incidental; or in case of demand children will be sent out to find turtles or their eggs. The heavy Sea turtles can easily be waited for on the beaches when they come to lay their eggs and are completely helpless against being killed; their rookeries are taken as monopolies by nearby human populations.

There are classic examples of the early excessive utilisation of both tortoises and Sea turtles. Most of the Galapagos and Indian Ocean tropical islands were historically crowded with Giant tortoises, as we now know it only from Aldabra. The tortoises became an important source of fresh meat to the seafarers and were taken on board by the hundreds as they could be stored without water and food, staying alive for around a year. As a result most of the island tortoise populations, except those on some of the Galapagos and the Aldabra islands, had become extinct by around 1800 (1). Similarly, some of the Sea turtles, such as the Green and Hawskbill turtle, were excessively exploited since early times for food and shells as a valuable raw material until the species' survival became endangered.

Table 5: Overview of the utilisation of tortoises and turtles

English name	Scientific name	Geographical distribution	Body[1] length (cm)	Utilisation
FRESHWATER TURTLES and TERRAPINS - EMYDIDAE				
Sliders	*Pseudemys scripta* sspp.	N.America	10-20	farmed for pet trade
Diamond-back terrapin	*Malaclemys terrapin* sspp.	N.America	20-25	farmed for meat
Spotted Pond turtle	*Geoclemys hamiltoni*	W.-S.Asia	20	for eggs, pet trade
Reeves' turtle	*Chinemys reevesi*	E.Asia	20	for meat and
Box turtles	*Cuora* spp.	S.-S.E.-E.Asia	20	medicinal purposes
Asian River turtle	*Callagur borneonensis*	S.-S.E.Asia	30-60	for eggs, pet trade
Roofed turtles	*Kachuga* spp.	W.-S.Asia	20-25	for meat, medicine
Indian Black turtle	*Geoemyda trijuga*	S.Asia	20-25	and pet trade
TRUE TORTOISES - TESTUDINIDAE				
Mediter. tortoises	*Testudo*[2] *hermanni, -graeca*	S.-SE.Europe	10-20	for pet trade
Steppe tortoise	*-horsefieldi*	C.-W.Asia	20	for meat, pet trade
African tortoises	*-pardalis, -sulcata, -angulata*	African south of Sahara	25-75	for subsistence, pet trade
Asian tortoises	*-elegans, -elongata, -emys*	S.-S.E.Asia	25-40	for meat, pet trade
S. American tortoises	*-carbonaria, -chilensis*	S.America	25-50	for meat, pet trade
Giant tortoises	*-gigantea, -elephantopus*	Indian Ocean and Galapagos Islands	> 100	formerly for meat, now tourism
Hinged tortoises	*Kinixys* spp.	W.-C.Africa	20-30	for subs., pet trade
Parrot-beaked tortoises	*Homopus* spp.	S.Africa	10-20	for pet trade
Pancake tortoise	*Malacochersus tornieri*	E.Africa	10-15	for pet trade
SEA TURTLES - CHELONIIDAE				
Olive and Kemp's Ridley turtles	*Lepidochelys olivacea, -kempi*	tropical and sub-tropical oceans	100	for eggs, meat, leather
Hawksbill turtle	*Eretmochelys imbricata*	tropical oceans	90	for shells, meat; exp. farming
Loggerhead turtle	*Caretta caretta*	trop./subtr. oceans	100	for eggs, meat
Flatback turtle	*Natator depressus*	tropical oceans		for eggs, meat
Green turtle	*Chelonia mydas*	tropical oceans	100-140	for meat, eggs, shells; farming
LEATHERBACK TURTLES - DERMOCHELYIDAE				
Leatherback turtle	*Dermochelys coriacea*	tropical oceans	120-180	f. meat, leather, oil
SOFTSHELL TURTLES - TRIONYCHIDAE				
Ind. Flapshell turtle	*Lissemys punctata*	India	25	for meat, medicine
Ind. Softshell turtles	*Aspideretes* spp.	S.Asia	40-70	and pet trade
Other Softshell turtles	*Trionyx* spp.	W.Africa, S.W.-E.Asia	25-90	farmed for meat, pet trade
SIDE-NECKED TURTLES - PELOMEDUSIDAE				
Arrau and Terecay	*Pedocnemis* spp.	trop. S.America	40-100	for eggs and meat
African Side-necked turtles	*Pelomedusa* spp. *Pelusios* spp.	Africa south of Sahara, W.Africa	20-25	for meat, pet trade

1) maximum length of carapace according to MLYNARSKI and WERMUTH (12); 2) the large number of *Testudo* spp. has been divided into the following subgenera: *Testudo* (S.Europe - N.Africa), *Pseudotestudo* (N.E.Africa), *Geochelone* (N.W.-C.-S.Africa and S.Asia), *Psammobates* (S.W.-S.Africa), *chersina* (s. Africa) *Asterochelys* and *Acinixys* (Madagascar), *Aldabrachelys* (Aldabra islands), *Agrionemys* (W.-C.Asia), *Manouria* and *Indotestudo* (S.-S.E.Asia), *Chelonoidis* (trop. S.America, Galapagos Islands)

With this general background in mind particularly careful consideration has to be given to the possibilities of sustainable and controlled forms of management and utilisation of the chelonian resources.

TORTOISES AND FRESHWATER TURTLES

Past and present utilisation

Most of the larger chelonians have been and are still used by collecting their eggs for food, killing them for meat, and making a variety of artefacts out of their shells; in some countries, such as India, turtle shells, blood and gall-bladders are utilised for medical purposes (5). More recently collection of live specimens for international trade and the farming of some of them have become additional important uses.

Most of the tortoises, as well as species from fresh and brackish water, have been and are still being used extensively for **subsistence purposes**. In most tropical countries any type of reptile, but particularly tortoises and turtles, is readily and even preferably consumed (7). Only where there are urban markets nearby may some of the collected turtles or their eggs also be marketed as food. Of particular importance in this respect are the *Side-necked turtles* (*Pelomedusidae*) in the waters of the Amazon rivers and the West African lagoons. In a survey of 23 restaurants in Manaus in 1976, turtle dishes (*Podocnemis* spp.) were, amongst all wild-animal food, in greatest demand and widely preferred by the general public (15). *Pelusios* and *Pelomedusa* turtles are found in numbers on every urban market along the coast of West Africa. In a survey in India it was found that of 26 turtle and tortoise species present 22 were utilised to a varying degree for food and/or medical purposes throughout their distribution range (5). Egg collection has also taken place from the nesting sites of the *River terrapin* (*Batagur baska*) and the *Asian River turtle* in South-East Asia (6, 13). *True tortoises (Testudinidae)* are taken for food anywhere in the drier parts of South America, Africa south of the Sahara, and to a lesser degree also in Asia; however, this is mostly incidental. Nevertheless, in a 12-month investigation in two localities along the Transamazon highway in 1973/74, tortoises (*Testudo (Chelonoidis)* spp.) constituted almost 2 % and 4.1 % respectively of wild-animal foods eaten (14).

Large scale **commercial exploitation** of *Podocnemis expansa* and *-unifilis*, the *Arrau* and *Terecay turtles*, formerly existed in Brazil. Perhaps more than 50 million eggs per year were harvested on the river shores of the Amazon, not only for food but mostly processed into an oil for candles (12). In Asia, where the consumption of Freshwater turtles is widely believed to have also medical effects, subsistence use has locally developed into commercialisation of turtles. Examples are *Box turtles*, and more recently mainly *Reeves' turtles*, in China, and the *Flagshell* and *Softshell turtles* in India which are systematically collected for market sale despite protective legislation. They are fished in nets, and iron pokers are used to pull out turtles burried in mud (5). In the former USSR, immense numbers of the *Steppe tortoise* have been processed into food for fox farms (3).

Apart from the immeasurable subsistence use, the most extensive utilisation of tortoises and Freshwater turtles world-wide is probably their **live capture for the pet trade**. This often

concentrates on hatchlings which sustain very large mortality rates during trade. For example, in the 1960s hatchlings of *Podocnemis unifilis* were exported in large numbers to Europe and North America as pets, probably in imitation of the almost industrial farm production of *Red-eared sliders* (*Pseudemys scripta elegans*) in the USA for the pet trade (8). Hatchlings of the various subspecies of this turtle are still the most commonly traded pet turtles. They are shipped in hundreds of thousands of which less than 1% might survive captivity. Tab. 6 gives a perspective of the trade in live tortoises under the provisions of CITES in 1989 to 1993. The most heavily traded species until 1992 were *Testudo horsefieldi* and the *Kinixys* species, predominantly *-belliana*. The next in importance were still the Mediterranean *T. graeca*, *-hermanni*, *-marginata* and *-kleinmanni*, followed by the African *T. pardalis* and *-sulcata* and the Asian *T. elegans*. The formerly so important trade in Argentinean *T. chilensis* has dropped to almost nil. Exports of *T. (Indotestudo) elongata* from Malaysia and Bangladesh mainly into Hongkong, Singapore and China, was partly recorded in weight. According to the weight figures the trade in these species, most probably for food, must be substantial. Trade in *Side-necked turtles*, *Pelomedusa* and *Pelusios* spp., from Africa, has also been quite considerable.

Table 6: CITES registered trade in live tortoises in 1989-1993[1)]

Species	1989		1990		1991		1992		1993	
	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.
T. (Testudo) graeca, -hermanni, -marginata.	8,455	1,216	1,821	303	2,181	207	4,436	887	878	171
T. (Pseudotestudo) kleinmanni	157	47	1,011	0	277	180	303	356	10	20
T. (Agrionemys) horsefieldi	560	52,328	10,326	3,698	1,001	23,184	7,857	9,216	0	1
T. (Geochelone), mainly *-pardalis, -sulcata, -elegans*	1,454	605	3,552	2,663	7,178	1,391	4,969	4,290	313	1,197
T. (Chersina) angulata	97	109	102	58	88	47	151	198	80	24
T. (Chelonoides) carbonaria, -chilensis, denticulata	1,809	1,244	592	391	3,188	1,985	1,691	1,995	101	776
T. (Indotestudo), mainly *-elongata, -emys*	611	1,284	933	1,907	178[2)]	291	872[3)]	900	22[4)]	1
T. (Manouria) spp.	38	274	419	1,711	262	184	21	38	0	0
Malacochersus tornieri	0	0	603	0	5,572	301	740	172	0	0
Homopus spp.	17	82	36	38	24	14	55	79	15	2
Kinixys -belliana, -erosa, -homeana	15,628	9,422	9,305	6,376	7,336	10,720	4,411	6,700	0	3,731
Total Testudinidae	**28,826**	**66,611**	**28,700**	**17,206**	**27,285**	**38,504**	**25,506**	**23,721**	**1,419**	**5,923**
Total Pelomedusidae	**1,785**	**4,943**	**3,287**	**5,069**	**2,905**	**5,277**	**4,725**	**7,514**	**109**	**4,323**
Total Trionychidae	**38**	**274**	**86**	**11**	**34**	**290**	**515**	**377**	**0**	**9**

1) compiled from CITES data base extracts; 2) plus 79 t; 3) plus 280 t; 4) plus 721 t

There have been attempts to **farm turtles for commercial purposes** in addition to the above-mentioned slider farming for the pet trade and the breeding of tortoises and turtles for replenishing wild populations (8). The *Diamond-back terrapin* was farmed on the east coast of USA for the production of turtle meat for gourmets (9). Historically, of course, this species was extensively used to feed the slaves in Southwestern USA. Enclosures with water which changed at high and low tide were constructed to contain and breed this salt

marsh species, sometimes attaining a body weight of more than 1 kg. The farm was profitable for 30 years after which, at the beginning of the Second World War, it was abandoned. The rearing of *Softshell turtles (Triochynidae)* has a long history in East Asian countries, particularly China and Japan. In Taiwan they have been bred and farmed for more than a century (4) for human consumption. Large-scale commercial farming of *Trionyx sinensis* in preference to the local *T. cartilagineus*, was initiated in Singapore in the 1970s. One farm cultures 30,000-40,000 turtles in ponds and sells 400-500 per month when they have attained a weight of 0.6 kg (2). They are marketed alive to local restaurants where they are made into soup which is said to have medicinal value.

Apart from the consumptive uses tortoises and turtles were **of cultural importance** to many early societies as is still reflected from mythology, art and religion in some regions. In Asian countries, such as Thailand and also Japan, large numbers of turtles (*Hieremys annandalis* and *Siebenrockiella crassicollis*) are kept in ponds around temples and castles, fed by the public and higly revered. In Thailand it is believed that the souls of people who have died in attempts to save others from drowning live in them (12).

Economic importance

The value of tortoises and Freshwater turtles and their eggs to subsistence economies in tropical countries is probably much greater than that of the Sea turtles. This is simply due to the fact that there are some 260 species widely distributed over all continents as opposed to the 7 species of Sea turtles utilisable only on certain coasts or in some tropical waters.

In addition to this subsistence value, the international trade in live tortoises and turtles for use as pets has become most important economically since the 1960s when it became fashionable in industrialised societies to keep any type of small, convenient wild animal as a hobby (10). Initially the tortoise pet trade was largely limited to the Mediterranean species (*Testudo*). As these became rarer, large numbers of *Horsefields* or *Steppe tortoises (T. horsefieldi)* from West and Central Asia, and *Chaco tortoises (T. chilensis)* from Argentina were imported. UK imports of the Mediterranean species during 1965-1975 averaged 200,000 per year; total international trade in this period was estimated at 5-10 million tortoises (11). In 1976 some Emydidae, Trionychidae and Pelomedusidae were placed on Appendix I of CITES (no trade allowed) and all Testudinidae on Appendix II (trade only with export permits); they have thus become subject to trade restrictions. In 1984 the European Union banned the importation of the Mediterranean species altogether. Tab. 6 shows that the trade volume has since diminished greatly. The CITES statistics on which this table is based should theoretically comprise all commercial traffic in tortoises. That this is not so is clearly indicated by the great discrepancies between export and import figures and the continuance of significant internal trade in chelonians, particularly in Asian countries (6, 5). During a trade survey in India in 1991-92 more than 1,500 *Starred tortoises (Testudo elegans)* were confiscated on markets and internal trade in this species was estimated to be about 5,000 animals per year. At a price of US$ 65-300/tortoise in the United States the total export value of this trade alone was thought to be in the region of US$ 500,000 (5). Accepting that there is substantial unrecorded or illegal trade, as evidenced by occasional seizures of large falsely documented shipments, the CITES statistics nevertheless give an

Marketing of live Indian Softshell turtles, weighing up to 20 kg, for human consumption. (Photo: N.K. DAS; by courtesy of WWF-India)

indication of which tortoise species are mainly traded and what the trend of the trade has been during the period 1989-1993.

Registered exports of Testudinidae generally decreased from more than 66,000 in 1989 to about 6,000 in 1993 and the imports from about 30,000 to just 1,500. The number of specimens derived from the wild is probably lower, as the CITES export figures also include bred and re-exported tortoises. Even if one takes the figures to represent only a fraction of the total trade in live tortoises, this has dropped world-wide to economically rather insignificant levels compared with the volume of the pet trade in the 1960s and 1970s, mentioned above.

There are, however, indications that the traffic in *Freshwater turtles* in South, South-East and East Asia for consumption has been increasing. In a market survey in India in 1992 (5) this trend has been attributed to the following circumstances:

- Growth of fisheries activities in all kinds of waterbodies in which turtles are considered detrimental to the fish resources;
- With a market and pricetag, turtles provide an extra source of income to the fishermen;
- Increase of fish and meat prices rendering turtle meat a cheap and particularly healthy substitute;
- Traditional beliefs attached to the consumption of meat and other products of turtles;
- Migration of Bangladeshis into India where they constitute the bulk of buyers in Calcutta, the most important turtle market.

On 61 food markets surveyed 12 were engaged in the sale of turtle meat with prices ranging between Rp 15 and 200/kg depending on the locality. *Large Softshell turtles (Aspideretes gangeticus)*, weighing 15-20 kg, were fetching Rp 600-800/piece (approx. US$ 23-31) on the basis of the Calcutta market prices (5).

Breeding or rearing of tortoises and turtles in captivity for commercial purposes is also increasing but is still not nearly satisfying the pet market demand. Farming of turtles for human nutrition has theoretically two favourable aspects: as cold-blooded animals they consume only roughly 1/15th of the food a warm-blooded animal of the same size requires, and if herbivorous they convert plant material, otherwise non-utilised, into protein. However, even turtles of large body size, like the *Arrau*, can never compete with the productivity of other aquatic animals like fish. Therefore, it is difficult to make farming of smaller turtle species commercially profitable. One turtle farm in Singapore, for example, holds a stock worth Singapore $ 240,000-360,000 (approx. US$ 112,000-168,000) but makes only a small profit (2). Export of live turtles from this farm to Japan in 1980/81 was found to be economically not viable.

Implications for conservation

Commercial exploitation of riverine and lacustrine turtles for food, as occurs in Asia, is a cause of worry for all those species which are either endemic or have a low reproductive capability. In India, the two brackishwater species, the Giant Softshell turtle (*Pelochelys bibroni*) and the River terrapin (*Batagur baska*) have been practically wiped out because of over-exploitation (5). Considering the longevity of tortoises and turtles even uncontrolled collection of their eggs, as has occurred for decades with the Arrau and Terecay turtles in the Amazon region for example, will certainly have a negative effect on their long-term reproductive success visible only after decades. However, the increase in human activity on tropical river courses, occupation of their banks and deforestation are probably a more important threat to the Freshwater turtles than their present exploitation. Also, there cannot be any doubt that the collection of tortoises for the international pet trade has already contributed substantially to the decline of a number of the *Testudo* species, notably *T. graeca*, *-marginata*, *-hermanni* and *-chilensis*. However, in the arid and semi-arid environments in which most of the tortoises live, fire and habitat destruction along with agricultural intensification are greatly compounding the effect of collection. In contrast to the case of the Sea turtles on which much more conservation concern is being focused, very little research has been done so far on the population dynamics of Freshwater turtles and tortoises that would allow the design of appropriate management programmes, apart from the fact that it is almost impossible to control their subsistence use. Therefore, at present it would appear to be best to curb the import of pet tortoises from the countries of origin, as the European Union has done successfully since 1984, and to promote breeding programmes as much as possible. Apart from alleviating the trade pressure breeding programmes may also eventually contribute more significantly to the replenishment of depleted species in the wild; for example, the breeding of *Testudo sulcata* in Senegal for release in protected areas of the Sahel zone.

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SEA TURTLES

Past and present utilisation

The Green turtle has been called "the world's most valuable reptile" (e.g. 39). As CARR (1962) put it: "Three requisites for a valuable and controllable marine food resource suggest themselves: it ought to be big; it ought to be herbivorous, or at least close to the base industry in the feeding chain; and it has got to be edible." The Green turtle meets these requirements. There are vast areas of sea grasses "growing in steady spreads over endless miles of tropical ocean bottom. Today most of these pastures are empty" (18), in part a consequence of the reduced numbers of turtles from the profusions that sustained Columbus and other explorers on their voyages (39).

All species of Sea turtles have been used in historical times by indigenous people for **subsistence purposes** and currently this continues in many parts of the world. Current utilisation of turtles varies from occasional unintentional catch in nets to systematic harvesting of turtles or their eggs. In some parts of Indonesia, a subsistence culture centres around hunting *Leatherback turtles* (22). In one village in Honduras, 72% of the households (n=93) earned some income from turtle eggs and this was estimated to account for 4.3% of the expenditure of an average household (29). The extent of local use of turtles is often difficult to quantify, but steady small scale take by individuals could add up to considerable totals. It is estimated that 10,000 turtles are killed each year by islanders in the Torres Strait (38).

In terms of the cash value of **international trade in turtle products**, the *Hawksbill* is now more important than the *Green turtle*. In 1979 the shell of a good sized Hawksbill turtle could sell for US$ 200 (20). The main exports have been from Indonesia to Japan where the shell is called "bekko" (32, 33). This could change now that Japan has withdrawn its CITES reservation on hawksbills.

Other principal uses of turtles include leather, especially from *Olive Ridley turtles* from Mexico and Ecuador, calipee of Green turtles for soup and the eggs of all species. The oil, especially of *Leatherback turtles*, is used for lamps and for medicinal purposes; turtle oil is also used in soaps and cosmetics. Stuffed turtles, usually juveniles with thinner less valuable scutes, are sold as curios. Although the Green turtle is primarily used for food, the Hawksbill for shell, and the Olive Ridley turtle for leather, these categories are not exclusive. Leather can be made from species other than the Ridley. Some Green turtle shell is sold internationally (32). Only those with no appreciation of the power of modern technology would altogether discount the possibility that some form of welding or treatment of Green turtle shell would make it an acceptable substitute for the thicker shell of hawksbills; even without special efforts, the scutes of captive reared Green turtles are thicker than those of wild turtles. All species of Sea turtles have been eaten, though there seems to be a greater chance of food poisoning from Hawksbill turtle meat.

Green Sea turtle hatchlings in an experimental farm in Suriname in 1982. (Photo: N. MROSOVSKY)

With the realisation that supplies are not limitless, a number of protected areas for the conservation of Sea turtles have been established in the last century; there have also been some **attempts to farm and ranch Sea turtles** (43, 40). At the Cayman Turtle Farm, *Green turtles* are processed at 3-4

years old when they weigh about 24 kg. The turtles are fed on modified Purina trout chows and costs of food in the early 1980s were about US$ 1.50 per kg body weight produced. Tanks are made of concrete or fibreglass; sea water is pumped in continuously. The breeding herd is kept in a large 3 m deep pond with a sand beach at one end; about 5 m^2 surface is allowed for each of these turtles. Once females start breeding at the Cayman Turtle Farm, their average interseasonal nesting interval is 1.6 years. Mean annual egg production is estimated at 375 (45). Second generation Green turtles have been produced in captivity (44); given time for research, large-scale production would probably be feasible. However, ranching is preferred to farming by some because it makes utilisation dependent on having a healthy population in the wild (28) and because the collection of eggs can be linked to contributions to conservation which could be greater if the considerable expense of keeping breeding herds were avoided (35).

Economic considerations

The economic value of Sea turtles depends on which parts of the animal are used. A beautifully polished hawksbill shell might sell for several hundred dollars, making the rest of the animal relatively worthless; but in places where tourists are few, or CITES trade regulations rigorously enforced, the meat or eggs might be valued for local consumption.

An important biological point is that Sea turtles can reproduce over many seasons. A *Green turtle* has been found nesting 24 years after being first tagged (BJORNDAL, pers. comm.). Assuming an average breeding interval of 2.5 years, that gives more than 9 seasons in which eggs can be laid; at around 3 clutches a season (see (19) for elaboration), of about 100 eggs per clutch, this gives a potential lifetime production of 2,700 eggs. This is probably an underestimate because when saturation tagging of nearly all females coming ashore to lay is undertaken, nesting frequency per season is usually found to be higher than first thought (42). Of course it is not known for how many seasons an average Green turtle survives, but as an order of magnitude estimate, a *potential* of at least 3,000 eggs in a lifetime is not unreasonable. The question then arises as to whether it is best to use turtles for meat or for other purposes.

Calculations of the worth of eggs relative to other parts can be most easily done for the *Leatherback turtle* for which the value of the carapace (which lacks scutes, and rots easily) can be excluded, except perhaps for extraction of some oil. An example is given for leatherbacks on the west coast of Mexico in the late 1970s. Obviously the prices and details have to be changed for different places and times, but the example shows the kinds of considerations that those wanting to manage Sea turtles might wish to contemplate.

Value of meat		Value of eggs	
mean carapace length	147 cm	clutch size	70 eggs
weight	295 kg	price per egg	8 pesos
estimated weight of meat	103 kg	value of clutch	560 pesos
price of meat locally	60 pesos/kg		
total value of meat	6,192 pesos		

Assuming the average leatherback lays six times per season, and assuming that one clutch is collected when the turtle is killed for meat:

total value if turtle killed = 6,192 + 560 = 6,752 pesos
total value of eggs over season = 6 x 560 = 3,360 pesos.

The basis for these estimates is given elsewhere (35), but even allowing for errors it seems likely that a Leatherback turtle only has to stay alive for two seasons for the eggs to be worth more than the meat. It comes down to the fact that leatherbacks are capable of producing thousands of eggs in their lifetimes. Killing for the meat, or to obtain the eggs without having to wait for laying, might be the best short-term strategy for an individual who may not find that turtle again or a poacher who wants to make a quick getaway. But the long-term interests of a community would be better served by harvesting eggs.

Calculations such as those above are only a guide. They would have to be adapted for particular species and locations, refined to take interest rates into account, and elaborated for species with valuable shells, or when there is a potential of the turtles attracting revenue from tourists. Much depends on over how many seasons a turtle lays. The longest recorded interval between the original date of tagging at laying and a subsequent laying is 20 years for *loggerheads* (RICHARDSON, pers. comm.), and 24 years for greens. Even though the average duration of reproductive life could be much shorter, enough is known to think that, for utilization as food, harvesting of eggs is preferable to killing turtles for meat.

Implications for conservation

The drastic decline in numbers of Leatherback turtles nesting in Terengganu in Malaysia has been generally attributed to the overharvesting of eggs over many decades (23, 28). This may well be true but it is hard to prove. Without control areas, other factors cannot be ruled out. Many Leatherback turtles were caught in nets in Terengganu in the mid 1980s (estimated at 376 per year by (21)) and it is remarkable that almost total harvests of eggs from some other rookeries, those of Olive Ridley turtles in Honduras for example, have not wiped out the turtles there (29). Nevertheless, egg harvesting should not be undertaken lightly. Fortunately, there are some schemes that appear to be relatively safe. The most conservative is to use eggs that are naturally doomed to destruction. Tab. 7 shows that in Suriname about a third of the leatherback eggs are laid below the high-tide line and subsequently washed away. Continued monitoring of the percentage of eggs that are doomed, with attention to seasonal variations, would be a desirable component of an egg-harvesting programme. Nevertheless, the available data suggest that order-of-magnitude estimates can be obtained from limited sampling. On some beaches, difficult access or other logistic problems may make it impractical to market eggs only from nests that are actually laid below the high-tide line. Instead, as is done in Suriname, some tidally doomed eggs may be reburied higher up the beach to compensate for those taken to market (41, 35, 28). There is no evidence that particular individuals tend to lay tidally doomed eggs (27) and therefore saving such eggs should not degrade the gene pool.

Table 7: Percentage of Leatherback turtle eggs estimated to be laid below the high tide line (doomed) in Suriname

Beach	Year	No. laid	% doomed	References
all Suriname	1971	24,000 eggs[1)]	ca. 46	SCHULZ 1975
	1972	36,000 eggs	ca. 44	SCHULZ 1975
	1973	75,000 eggs	ca. 37	SCHULZ 1975
Krofajapasi	1980	39 nests [2)]	36	MROSOVSKY 1983a
	1982	196 nests	32	DUTTON and WHITMORE 1983
Matapica	1993	195 nests	50	GODFREY, pers. comm.
Baboensanti[3)]	1982	9 nests	78	MROSOVSKY 1989
	1993	12 nests	83	MROSOVSKY, unpubl.

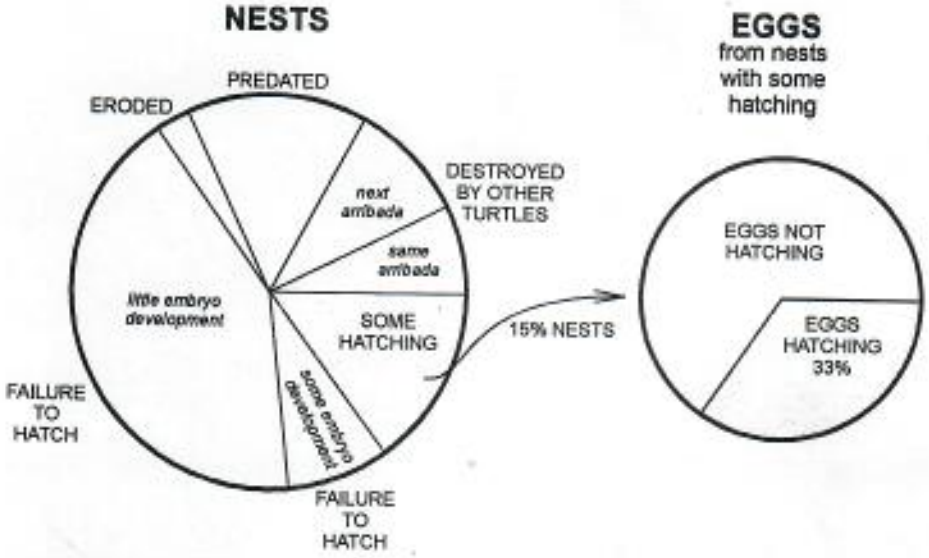
1) calculations based on disposition of eggs; 2) early June; 3) this relatively inaccessible beach was visited in early May in 1982 and again in 1993

Nests laid too near the sea, though perhaps the easiest to identify, are only one source of natural mortality at an early life stage. On the island of Europa in the Indian Ocean, about 8% of Green turtle hatchlings emerging do so by day (31): few escape the sharp-eyed sharp-beaked frigate birds. By patrolling the beach in the late afternoon, a time when daylight emergences are common, hatchlings can be saved from the birds. Such hatchlings have been used to stock turtle ranches. Even if one does not know whether a particular hatchling would have escaped on its own or not, one may be confident that most of the hatchlings harvested in these circumstances would not have survived. Lest there is some biological advantage related to daylight emergences, some of the hatchlings saved from the birds should be released. To guard against changes in frequency of genes influencing particular behaviours, as management schemes become entrenched, monitoring of the percentage of hatchlings emerging by day should be continued. Also it would be desirable to learn whether particular individuals tend to produce nests that emerge by day or whether these occurrences are more related to external conditions.

Sea turtle nest that has been exposed by high seas in Suriname. Crabs and vultures are likely to eat these eggs and the rotting remains will become infested with flies. Nests classified as doomed are generally laid even lower with respect to tide lines than the present one, and are simply washed away. (Photo: N. MROSOVSKY)

Natural loss of eggs is also caused by the turtles themselves, especially by Ridley turtles whose *"arribadas"* (mass nestings) occur on short stretches of the beach. Fig. 4 shows that at Nancite, Costa Rica, ca. 17% of Olive Ridley nests are destroyed by turtles nesting later. Even if nests are not dug up, their chances of producing many viable hatchlings are small. Microbial contamination of the soil might be responsible. Whatever the cause, the huge egg wastage at arribadas offers an opportunity for utilisation without detriment and even possible benefit to populations: it is thought that reducing the density of nests will increase the survival rates of those remaining (17, 24), though definitive research is lacking.

Figure 4: Fate of Olive Ridley turtle nests and eggs at Nancite, Costa Rica (after CORNELIUS (23))



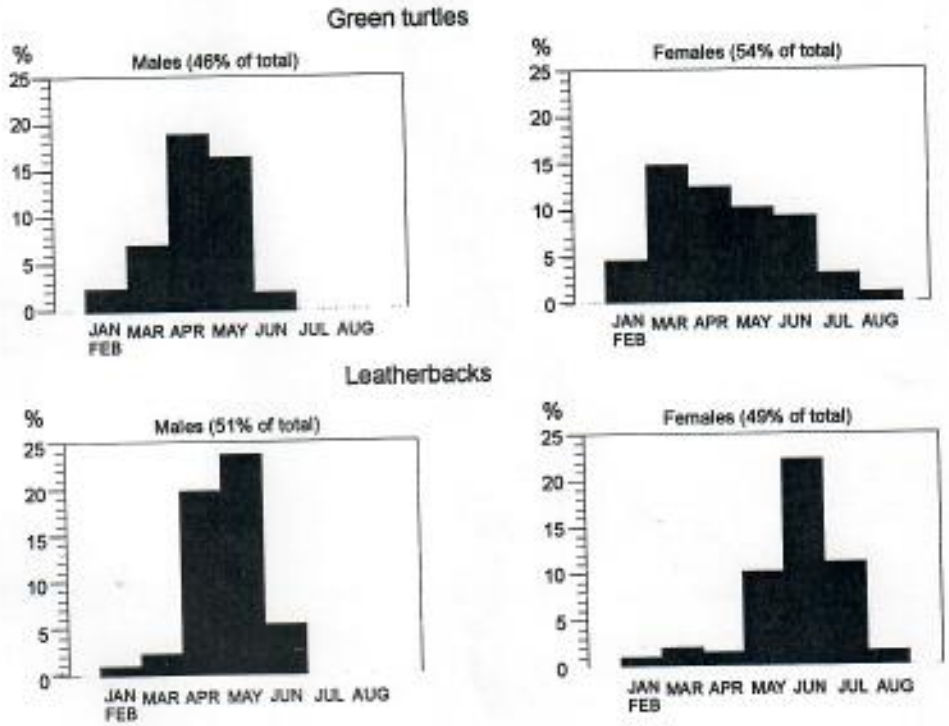
At Ostional, Costa Rica, egg taking by the villagers has been legalized during the first 36 h of an arribada nesting since eggs laid early in an arribada have a greater chance of being destroyed than those laid later. The eggs are then marketed at prices comparable to those of chicken eggs, thus undercutting egg poachers (16).

The above give some examples of naturally destroyed eggs. These particular factors are not prominent on every turtle beach. The general point is that sources of mortality at this early life stage can be studied (36). Taking steps to reduce this mortality can free eggs for human consumption without making inroads into recruitment. If some of the saved eggs are protected and the hatchlings released, recruitment may actually be increased.

Attention should be given not just to numbers in managed populations but to sexual composition. In Sea turtles, sexual differentiation is determined by temperature. This is not a problem if eggs are taken occasionally, for example to start a farm, or if only eggs that are certain to be doomed are taken. But if eggs are harvested within a fixed open season every year, with compensatory relocation of doomed eggs going on throughout the season, then

there is a danger of distorting sex ratios. To avoid this some idea is needed of the seasonal sex production profiles (SSPPs), as illustrated in Fig. 5.

Figure 5: Estimated sex ratios of Sea turtle hatchlings in Suriname in 1982 (data from MROSOVSKY and coll. (37))



Estimates of the number of each sex produced at hatching are expressed as a percentage of the total number of hatchlings in the season and the X-axis shows laying dates. In the case above, if some harvesting were permitted for Green turtles in March and April, approximately equal numbers of male and female producing eggs would be taken, but if the same months were open for leatherback eggs, then the relative output of male leatherbacks would be decreased. SSPPs can be used in management plans, but should ideally be based on estimates from more than 1 year. This may not always be feasible because present methods of sexing hatchling Sea turtles require histology and are laborious. However, partial protection against introducing sex ratio biases can be obtained by not concentrating harvesting just at the warmest or the coolest time, combined with knowledge from laboratory work about the actual temperatures producing males and females.

Although it may eventually be possible to harvest adult turtles safely, at present it is much more risky. With egg harvesting linked to doomed eggs, it is possible to protect numbers of eggs equal to or greater than those taken. The protective measures and the take can be made in the same units: eggs. If adult turtles are taken, not enough is known about survival rates to say how many eggs should be saved or how many juvenile turtles should be head-started

to compensate for those adults. But with protein-rich eggs being washed out to sea by the tides, hatchlings which emerge by day being decimated by frigate birds, and turtles digging up each other's nests at arribada sites, some utilisation is surely possible at early stages in the life cycle. Moreover, controlled utilisation can support the activities of national wildlife authorities (40). Setting up reserves without adequate enforcement is often symbolic conservation leading to unregulated unmonitored utilisation (cf. 30).

Some conservationists advocate that more attention should be paid to the most reproductively valuable stages of the life cycle, the mature turtles and the large juveniles (25). This is not disputed but it should not be taken as an argument against using doomed eggs. The question that should be asked about egg harvesting is whether it is detrimental. If it is not, then there are common interests between those harvesting eggs in a controlled way based on the high natural mortality, and those whose priorities are protection at other life stages. Those utilising Sea turtles at the early stages will want their populations to be as large as possible. They are likely to support and promote efforts directed at preserving breeding adults.

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