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TURTLE CULTURE

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INTRODUCTION

Several turtle species have been produced commercially, including the soft shell turtle, *Trionyx sinensis japanicus*, in Japan; the red ear slider, *Pseudemys scripta elegans*, and the diamond back terrapin, *Malaclemmys terrapin* sp. in the U.S.A.; and the green sea turtle, *Chelonia mydas*, in the Cayman Islands, Surinam, Reunion and Australia (Fig. 14.1). The soft shell turtle and diamond back terrapin are cultured solely for food, the red ear slider for the pet industry, and the green sea turtle for food, leather and decorative products.

FRESHWATER TURTLE CULTURE

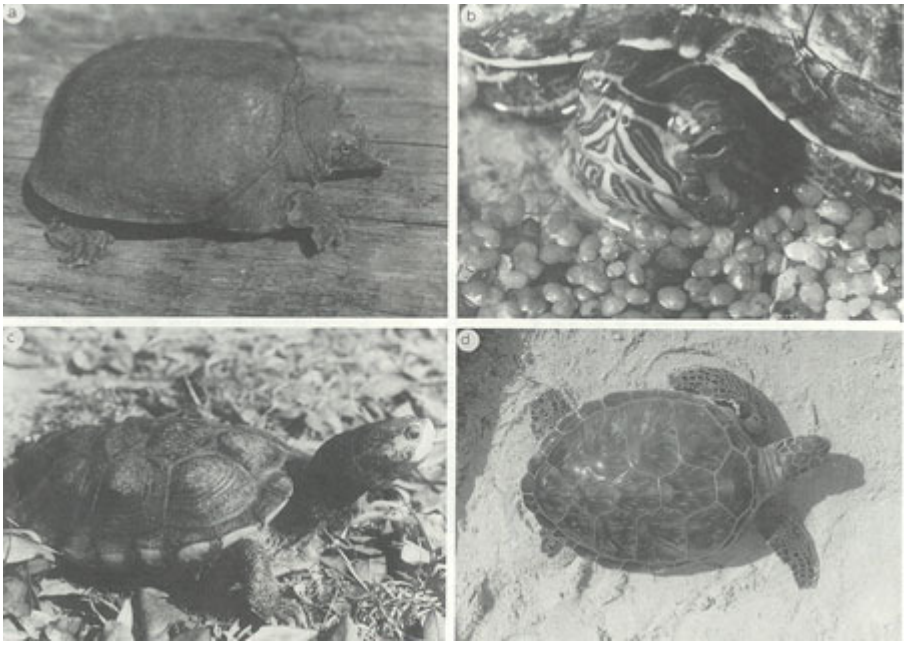
Historical

Pond culture of the freshwater species began from the turn of the century in small systems in both Japan and the U.S.A. (Mitsukuri, 1904; and Hildebrand, 1929). Kurajiro Hattori began the culture of the soft shell turtle, or suppon, as part of a polyculture enterprise together with goldfish, carp and eel in Tokyo as early as 1875 (Mitsukuri, 1904). He later moved and expanded his operation at Shizuoka. Central Japan continues to supply the majority of the nation's farmed turtle market, although the industry is expanding to the warmer areas of southern Japan.

Pond culture of the diamond back terrapin in the U.S.A. was developed along similar lines by the Bureau of Fisheries and private individuals in the early 1900's in North Carolina and Maryland. There is little commercial culture in the U.S.A. today, and most of the restaurant trade is supplied by wild-caught turtles. Pond culture of the red ear slider in Louisiana for the pet industry began in the 1960's and closely parallels the culture techniques for the terrapin and soft shell turtle.

The following sections describe parallel procedures developed and used in each of the three industries for freshwater turtle production in Japan and the U.S.A.

Figure 14.1
Representative views of (a)Trionyx sinesis,(b)Pseudemys scripta, (c) Malaclemmys terrapin, and (d) Chelonia mydas



Breeding stock

The mature, parental stock is maintained in one or more ponds varying in size from 30 m_2, to over 1000 m_2 depending upon the location of the farm and production capacity. The depth of the ponds varies from 1 to 4 m. The farms are generally located near canals or streams so that there is a continuous flow of fresh water into the ponds. In locations where there are tidal fluctuations, gates control the flow of water, always maintaining a minimum depth of approximately 1 m. The walls of the ponds are preferably poured concrete or laid with wood planks. The bottom of the pond has mud deep enough for hibernation.

For terrapin culture the ponds are located on gently sloping shorelines. An adjacent nesting area is provided which has a minimal depth of 0.3 m of dirt or sand above the high tide line, where applicable. An average of 1 m_2 of nesting beach is provided for each female. Male to female ratio for mating success ranges from 1 male to 1 female, to 1 male to 5 females. The periphery of the ponds and nesting areas are enclosed to prevent predation.

Nesting and hatching

Depending upon the location of the farm and its environmental parameters, nesting begins in March and April and continues through August. Each female lays 2-5 clutches per season, and 6-50 eggs/clutch depending on the species and size of the female. Inter-nesting intervals are reported to be 2-3 weeks. To prevent predation, destruction of nests by other females, and loss of hatchlings at hatch, eggs are collected following nesting, packed in dirt of sand, and incubated in enclosed hatcheries. Under natural conditions the eggs may hatch at 50-90 days. At 30 C, the soft shell turtles hatch at 50 days and the red ear sliders in 30-45 days. Hatching success varies between 80 and 90%.

After hatching, the hatchlings are transferred to hatchling pens with concrete bottoms. The hatchlings have a carapace length of 2.5-3 cm, and weigh 3-4 g. Mortality during the first 2-3 months is 10-15%, with little mortality after the first year.

One of two procedures is followed for grow-out. The turtles may be returned to grow-out ponds constructed similarly to the breeding ponds and left to hibernate over the winter months, or maintained in heated ponds to be fed throughout the year. Water temperature in the heated ponds is maintained at 22-24 C. Growth is approximately doubled by winter

feeding. Marketable size for both the soft shell turtle and the terrapin is a carapace length of 10-15 cm obtained after four seasons, or two years of continuous feeding.

The approximate growth and pond requirements for the soft shell turtle and terrapin (allowing for winter hibernation) are:

Age (years)	Size (g)	Pond surface area (m_2)
0-1	3-7	0.02
1-2	7-120	0.20
2-3	120-200	0.30
3-4	200-600	0.50

The red eared slider is marketed as a hatchling for the pet industry, therefore only maintenance of a breeding herd and replacement of breeders are required. Almost all mortality occurs the first few months following hatching, although the specific causes of mortality are not known. In older turtles, a disease known as "soft shell" has been reported in the terrapins and was associated with an inadequate feed supply (Hildebrand, 1929). A probable bacterial infection occurs in both the soft shell turtle and terrapin, and causes sores and edema of the carapace (Barney, 1923). The husbandry procedures practiced to maintain a healthy herd are periodic (seasonal) size-grading of the turtles, and treatment of the hatchling tanks with soluble antibiotics and sulphamides.

Feed

The first pond culture farms used a variety of locally obtainable fresh fish, salt fish, shell fish and chicken eggs as feed for the turtles. Commercially prepared pelleted feeds now provide a convenient, inexpensive and nutritional feed. Feeding regimes are not rigorously defined, but levels of pelleted feed range from 3 to 5% body wt. for the young turtles to 1% for the adult turtles. Estimated conversion for pelleted feed is 2:1. Feed is generally dispensed upon feeding boards or troughs attached to the periphery of the ponds or floated upon the surface.

The Salmonella problem

Commercial production of the red ear slider in the southern U.S.A. was an $8 million a year industry in Louisiana prior to May 1975. The turtles were raised and distributed nationwide as pets. A federal ban on inter-state shipment and sale of hatchlings, with a carapace length under 10 cm, was imposed in 1975. Hatchlings were found to carry and excrete Salmonella and Arizona bacteria, responsible for infections in humans. This ban caused a severe setback in the culture of the species (Kuzenski, 1976).

International trade in red eared sliders continues at an estimated level of 3-4 million turtles a year exported to Europe and the Far East. This trade currently maintains the industry in the U.S.A.

Treatment of the sanitised eggs with bacteriacides, such as gentamicin sulphate, terramycin and chloromycetin, may eventually result in the production of a Salmonella-free turtle (Michael-Marler et al., 1983). This would guarantee continuation of the international pet trade, and allow for reversal of the ban on domestic trade in the species.

Marketing of soft shell turtle an terrapin

The edible soft shell turtle cultured in Japan, and the terrapin in the U.S.A. , compete on the market with the wild-caught animals. State regulations applied to most of the

traditional turtle markets in the U.S.A. impose size and number restrictions on wild caught turtles, but the current market for farmed turtle remains small and turtle meat is considered a delicacy. At present, there are no large-scale commercial terrapin farms in operation in the U.S.A.
The Japanese soft shell market has expanded considerably since the 1960's. Production has swelled from less than 1 metric ton per year to over 500 metric tons in the late 1980's, with market prices in excess of US$9.00/kg (Kafuku and Ikenoue, 1983).

SEA TURTLE CULTURE

Historical

Wild sea turtles have been harvested for centuries to satisfy a large traditional international market. The green sea turtle, *Chelonia mydas*, supplied soup products for the "clear" turtle soup in the European market and meat products for the south-eastern U.S.A. The hawksbill turtle, *Eretmochelys imbricata*, supplied the tortoise-shell market of Japan. The ridley turtle, *Lepidochelys olivacea*, supplied leather products. In addition, many native coastal populations harvested sea turtles as their primary source of red meat.
Although wild-caught turtles have been pen-reared under varying degrees of sophistication for several centuries, large-scale commercial production of the sea turtle has developed only during the past two decades and then with the additional expedient to alleviate some of the demand on wild populations. All sea turtle species are now listed as endangered or vulnerable by the International Union for Conservation of Nature and Natural Resources due to extensive commercial exploitation, destruction of nesting beaches, and natural predation (Groombridge, 1982). Several approaches to sea turtle farming have been tried. For example, sea turtle culture on the island of French Reunion and in Surinam is based on harvesting a percentage of the wild population of eggs, or "turtle ranching". Both operations are land-based tank systems which use commercially available pelleted feed. Some hatchlings are released back to the wild to offset the possible decline of the wild populations.
A cottage industry culture of the green turtle was begun in Northern Australia in the late 1960s by the Applied Ecology Research Unit of the Australian National University (Carr and Main, 1973). The industry was designed to provide a livelihood for the inhabitants of the Torres Strait, and to supplant wild-caught turtles in the existing Australian market. The industry was begun with the design of collecting eggs from the wild to be hatched by the farmer, and the hatchlings reared to a commercial size. No provisions were made for maintaining a breeding stock, as the wild population of the area was able to supply the needs of the project without endangering the population. The turtles were reared in assortments of tubs, tanks and containers as available to the islanders. The turtles were fed ad lib fresh fish and vegetable matter as available.
By the mid 1970s the cottage industry was reorganized into five experimental turtle farms raising approximately 9000 turtles and employing about 60 islanders. By the early 1980s the Australian project was severely curtailed because of rising labour and administrative costs. In addition, the change from an irregular fresh fish feed supply to an expensive commercial pelleted feed had increased feeding costs to about US$6 per kg of turtle meat produced (Garnett and Murray, 1980; Onions, 1980).
In contrast to the labour-intensive culture of the green sea turtle in Australia, a capital-intensive culture of the green sea turtle was begun in the Cayman Islands in 1968. From its inception, the Cayman Turtle Farm, now incorporated as Cayman Turtle Farm (1983) Ltd. (CTF), has sought to develop a self-sustaining herd, independent of wild stocks of eggs, or wild breeding turtles. Until 1978, CTF collected eggs from the wild in Surinam,

Costa Rica and Ascension Island. After then, stock production was met by the captive breeding herd.
CTF has been marketing turtle products commercially since 1971. The farm was originally designed to raise turtles in floating pens protected in a tide estuary on the north side of Grand Cayman Island. The turtles were maintained on a diet of turtle grass, *Thalassia* sp., collected from beds abundant in the shallow waters surrounding the island. This was supplemented with an assortment of processed animals feeds and frozen fish. Later, the herd was moved to a land based tank system on the west side of Grand Cayman, and converted to a commercially prepared pelleted diet (Fig. 14.2).

Figure 14.2
Part of the facilities of Cayman Turtle Farm, (1980's) showing screened hatchling tanks in the forefround, the Farm's breeding pond and adjacent beach with visable turtle tracks , and 9m diameter concrete stone block stock tanks on the left. The farms hatchery is distinguishable in the background.

The following sections describe current husbandry and management practices for the culture of the green sea turtle at CTF:

Breeding stock

The original breeding herd, which first produced captive-bred hatchlings in 1973, was obtained through the purchase of wild, adult green sea turtles. To this herd, selected turtles from the Farm's own reared stock have been added. These captive-reared turtles, from eggs to adult, first produced hatchlings in 1975 at a minimum age of 8 years. The estimated age range of sexual maturity in captivity is 10-15 years, with size at sexual maturity ranging from 90 to 200 kg.
The breeding herd is housed in an excavated pond, approximately 3 m deep which slopes up to a beach with a sand depth for nesting of at least 1 m. The breeding pond is supplied with constantly flowing sea water with an estimated total water volume turnover rate of 1h. Optimum male to female ratio is about 1 to 4. Stocking density ranges from 4 to 6.5 m_2 surface area per turtle.
Two to four months before the beginning of the reproductive season, the males and females are separated. The reproductive season begins in April when the males are introduced to the females. Mating continues through June, and nesting normally lasts from May to September. Females do not nest annually, but the average interseasonal interval is 1.6 years. A nesting female lays approximately 600 eggs per season, in six successive clutches at 11-day intervals. Average annual egg production is therefore estimated at 375 eggs per female present in the herd (Wood and Wood, 1980).

Incubation and hatching

Eggs are collected as laid and incubated in sand-packed styrofoam ice chests in a hatchery maintained at 28-28.5 C (Fig. 14.3). Incubation temperature affects both relative hatch success (Wood and Wood, 1979) and the future sex of the turtles (Yntema and Mrosovsky, 1982). For the green sea turtle, incubation temperatures below 27 C produce predominantly males and incubation temperatures above 29 C produce predominantly females. After transfer to the hatchery the eggs are left undisturbed, except for periodic

moistening of the sand. At about day 55 the top layer of sand is removed, and hatching occurs at day 60.
The hatchlings have a yolk sac which, under natural conditions, is absorbed over a period of 2-3 days as the hatchlings move to the surface of the beach from the nest chamber. To allow yolk absorption, the hatchlings are kept in the hatchery for a few days before being transferred to water. Seasonal hatching success ranges from 15 to 60%.

Figure 14.3
Rows of styrofoam boxes containing eggs collected from Cayman Turtle Farm's breeding herd being incubated in the Farms temperature controlled hatchery.

Stock production and disease

At hatch, the turtles weigh less than 50 g and grow to a processing weight of about 24 kg after 3-4 years. The turtles are moved through a series of tank sizes and stocking densities to facilitate feeding and handling, and to optimize growth. Tank size and stocking density increase with the size of the turtle. Hatchlings are kept in small, rectangular tanks with an approximate volume of 600 litres, while the older turtles are kept in circular tanks with an approximate volume from 3000 to 130 000 litres (Fig. 14.4). Tanks are constructed of concrete block or fibreglass walls with concrete bottoms. Unfiltered sea-water is pumped continuously into the tanks at an approximate exchange rate of one volume per 20 min. During the first 12 months, water for the hatchling tanks is chlorinated at the rate of 1-2 ppm by adding granular chlorine to a holding tank on an hourly schedule. Periodic cleaning of the tanks is needed daily for hatchling tanks, and weekly for other stock tanks, to flush out waste and remove algae growth. Daily inspection of the tanks and removal of morbid and dead turtles is essential. Little mortality, less than 3% annually, is expected from 1 year until slaughter.
Several diseases have occurred among turtles raised under intensive culture conditions. These include a herpesvirus disease causing lesions on the skin and shell (Haines, 1978), a coccidia infection of the intestinal tract resulting in impaction (Rebell et al., 1974), mycotic pneumonia (Jacobson et al., 1979), ulcerative dermatitis caused by biting and resulting in secondary infection, and parasitic gastritis-serositis leading to lethargy and emaciation (Glazebrook, 1980). Outbreaks of disease appear to be the direct results of poor water quality, inadequate food supply and overcrowding. Most of these disease can be prevented by maintaining adequate feed levels and clean, fresh water. Water temperature influences the morbidity of some diseases, and temperatures greater than 25 C are the minimum desired for maintaining the health of the herd.

Figure 14.4
A 13000-litre fibreglass stock tank at Cayman Turtle Farm containing approximately 100 yearling turtles.

Feed

The turtles are fed a floating, pelleted diet. Until the turtles are approximately 1 year old, they are fed a modified Purina Trout Chow containing 40% crude protein, 8.0% crude fat, and less than 5.0% crude fiber. Older turtles, including the breeding herd, are fed Purina Turtle Chow containing 35% crude protein, 3.5% crude fat, and less than 5.0% crude fibre. Feed conversion varies from 1.2 to 6.5 units of diet as fed to unit of body weight gain, increasing with size of the turtle. The hatchlings are fed ad libitum, while the growing stock over 1 year old is fed a regulated daily ration decreasing from 2.0% body wt per day to 0.4% as the turtles grow. At feeding times, the floating rations are poured around the edges of the tanks. Feed costs in the early 1980s were approximately US$1.50 per kg body weight produced, at an average processing weight of 24 kg per turtle.

Marketing and economics

Capital-intensive culture of the green sea turtle is costly, and to be economically successful all of the marketable products must be sold. These include meat, skins, oil, soup products and shell.

Production of 5000 turtles per year (146,000 kg) for slaughter produces approximately 14,500 kg of fillet steak, 19,000 kg of steak pieces, 6800 kg of calipee/calipash (soup products), 4000 sets of skins, 8600 kg of oil, 545 kg of plastronal shell and 2000 polished whole shells. These products produce a gross income of approximately US$800,000. Because of the uniqueness of a turtle farming operation, tourist-related income of a large facility might generate US$500.000. With an average estimated expenditure of US$1,100.000, profitability is estimated at US$200,000 per year based on 1980's prices.

Sea turtle culture is a new and developing industry. Before the late 1970's, profitability in the industry was adversely influenced by several factors, including lack of proper technology and competition with products of wild-caught turtles. Since 1977, the green sea turtle has been listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES strictly regulates international trade among ratifying states of Appendix I species for commercial purposes. Although provisions are made in the regulations for trade in farmed or ranched populations of endangered species, there is considerable emotional pressure against trading in species whose wild populations are endangered or threatened. In order to market successfully the green sea turtle in traditional markets previously filled by wild turtle products, turtle farms or ranching operations must satisfy the regulatory controls of CITES.

CONCLUSION

Turtle culture is a relatively new enterprise. With the sea turtles, in particular, one is dealing with a slowly maturing species. The number of concerns working on the development of culture techniques and basic biological research, other than natural history and population dynamics, is small. The production of turtle species requires a long and strong commitment in time and money to obtain the degree of sophistication achieved in the farming of other, more common aquatic animals.

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