



FAUNA *of* AUSTRALIA



19. FAMILY CHELONIIDAE

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Pl. 3.1. *Caretta caretta* (Cheloniidae): the loggerhead turtle rarely breeds in Australia; occurs in tropical and warm temperate seas, along the entire northern Australian coast. [H. Cogger]



Pl. 3.2. *Eretmochelys imbricata* (Cheloniidae): the hawksbill turtle is common on coral reefs; rarely breeds in Australia; tropical and warm temperate seas along northern Australian coast. [H. Cogger]



Pl. 3.4. *Natator depressus* (Cheloniidae): the flatback turtle is endemic to Australia where it nests on beaches of the north coast. [H. Cogger]



Pl. 3.5. *Chelonia mydas* (Cheloniidae): adult green turtles are mainly herbivorous; they are circumtropical, and common from Shark Bay to south-eastern Queensland. [H. Cogger]



Pl. 3.6. *Lepidochelys olivacea* (Cheloniidae): the olive ridley turtle nests in western Arnhem Land; it is common along north coast and northern Cape York. [I. Morris]

DEFINITION AND GENERAL DESCRIPTION

The Cheloniidae, comprising the hard-shelled marine turtles, is one of only two surviving cryptodiran families from the past diverse marine turtle faunas (Pritchard & Trebbau 1984). The family is characterised by non-retractable, large, paddle-like flippers each with one or two claws, and keratinised epidermal scutes on the head, flippers, carapace and plastron. The ribs are fused to the overlying pleural bones which, in turn, are fused to each other to form the shield-like bony carapace in adults. The head can be withdrawn partially beneath the carapace, and there are no cusps on the upper jaw sheaths (Pritchard & Trebbau 1984).

The family is represented in Australia by five species, each referred to a separate genus: *Caretta caretta* (loggerhead turtle), *Chelonia mydas* (green turtle), *Eretmochelys imbricata* (hawksbill turtle), *Lepidochelys olivacea* (pacific ridley turtle), and *Natator depressus* (flatback turtle). All species have a worldwide distribution in tropical and temperate waters, except for *N. depressus* which is endemic to the Australian region. Data presented in this chapter refer to the Australian populations, unless otherwise indicated.

Cheloniid turtles have a chromosome number of $2n = 56$, with little detectable variability in chromosomal morphology between genera (Kamezaki 1990).

HISTORY OF DISCOVERY

Marine turtles have been known to coastal peoples since ancient times. The eggs and meat were used as food and the carapace scutes were used in constructing ornaments and utilitarian items as well as sacred objects. *Caretta caretta*, *Ch. mydas* and *E. imbricata* were described from the Atlantic Ocean basin by Linnaeus (1758, 1766). *Lepidochelys olivacea* (Eschscholz, 1829) was first described from the Philippines, and *N. depressus* was described from northern Australia by Garman in 1880 (Cogger, Cameron & Cogger 1983).

During early exploration in northern Australia, cheloniid turtles were sought actively for fresh meat. The keratinised scutes, or tortoiseshell, of *E. imbricata* were traded (Parsons 1962). Explorers like Dampier, Cook, Bligh, Flinders, King, Stokes and Jukes recognised *Ca. caretta*, *Ch. mydas* and *E. imbricata* (Jukes 1847), and their journals provide insights into the abundance and distribution of turtles at the time of early European contact with Australia. While the Australian endemic *N. depressus* had been described as early as 1880, its generic classification was not resolved for a further century (Limpus, Gyuris & Miller 1988; Zangerl, Hendrickson & Hendrickson 1988). *Lepidochelys olivacea* was not recognised as being part of the Australian fauna until 1969 (Cogger & Lindner 1969).

MORPHOLOGY AND PHYSIOLOGY

Details of morphology and physiology may be found in the synopses and recent reviews of the species—*Ch. mydas* (Hirth 1971), *Ca. caretta* (Dodd 1988), *E. imbricata* (Witzell 1983), *L. olivacea* (Marquez 1976) and *N. depressus* (Limpus *et al.* 1988; Zangerl *et al.* 1988).

External Characteristics

The weight of adult cheloniids ranges from 35 to >200 kg. Carapace length varies from 0.8 m for *L. olivacea* up to 1.2 m for *Ch. mydas*.

The carapace is oval to round and the head, carapace and plastron are covered in keratinised scutes. In *E. imbricata* the carapace scutes are thick and imbricate (Pl. 3.2), while in the other genera, regular flaking of the surface layers keeps

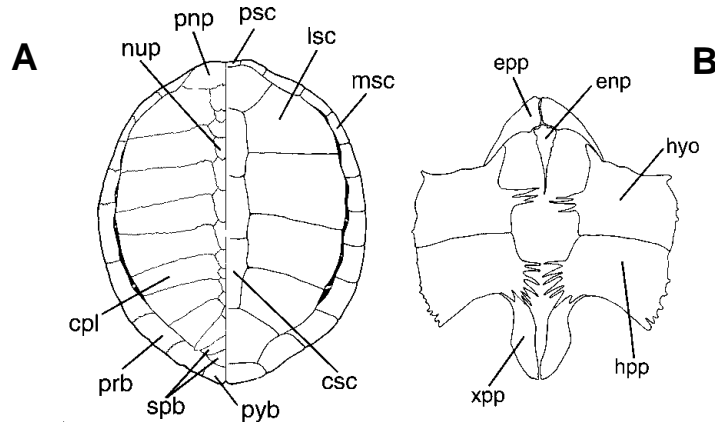


Figure 19.1 Carapace and plastron of *Natator depressus*. **A**, scutes and bones of the carapace; **B**, bones of the plastron. **cpl**, costal plate; **csc**, central scute; **enp**, entoplastron; **epp**, epiplastron; **hpp**, hypoplastron; **hyo**, hyoplastron; **lsc**, lateral scute; **msc**, marginal scute; **nup**, neural plate; **pnp**, preneural plate; **prb**, peripheral bone; **psc**, precentral scute; **pyb**, pygal bone; **xpp**, xiphoplastron. (After Zangerl *et al.* 1988) [T. Wright]

the scutes thin. In *N. depressus* (Pl. 3.4) the keratin layer is so thin that it has a skin-like texture similar to that of *Dermochelys corriacea* (Dermochelyidae) (Limpus *et al.* 1988). Cheloniid turtles vary in dorsal colour from uniform grey (*L. olivacea*; Pl. 3.6) to mottled black, brown and olive (*Ch. mydas*; Pl. 3.5) and are pale ventrally.

Hatchlings are also variable in colour, but tend to be darker dorsally than the adults. The dorsal colours of *Ch. mydas* and *Ca. caretta* are black and red-brown, respectively. Hatchlings of *E. imbricata* are brown, and those of *L. olivacea* are dark olive-grey to blackish dorsally. The carapace scutes of *N. depressus* are greyish with black margins (Pl. 3.3).

Cheloniids have elongate and paddle-like front flippers and short, oval rear flippers. The digestive tract and urinogenital system open into a common chamber, the cloaca, which opens to the outside through a single vent on the ventral surface of the tail. External sexual dimorphism is limited. In the pubescent or adult male, the tail is longer and the plastron is flatter or slightly more concave than in a female.

Body Wall and Skeletal System

The general skeletal and cranial morphology of all genera have been described by Deraniyagala (1939), Gaffney (1979), Pritchard & Trebbau (1984) and Zangerl *et al.* (1988). The relatively inflexible carapace consists of an outer epidermal layer with keratinised scutes, a thin dermal tissue layer overlying expanded dermal bones (pleural, proneural, neural, suprapygals, peripheral and pygal bones) which are fused to each other and to the underlying ribs and vertebrae. The plastron is less rigid, with substantial midline fontanelles reduced or contained by the nine plastron bones; it is not as cartilaginous as in the Dermochelyidae. The Cheloniidae has a typical anapsid skull, with an inner neurocranium encasing the brain and an outer dermal cranium encasing the extensive muscles operating the jaws and anterior neck. There is little emargination or reduction in thickness of dermal bone to lighten the skull (Fig. 16.4C, D).

Locomotion

When swimming, the Cheloniidae appear to fly through the water, using their front flippers as birds use their wings; the hind flippers function as rudders and elevators (Walker 1971). As with birds and bats, the thrust from the anterior girdles is transferred to a fused vertebral column for pulling the body forward. Though they are capable of speeds up to 4 to 7 km/hr over limited distances (Hirth 1971; Whitzell 1983; Dodd 1988), chelonians can maintain steady swimming for extended periods. *Caretta caretta* and *Ch. mydas* can maintain average speeds of 30 to 40 km/day over thousands of kilometres during migration (Limpus, Miller, Parmenter, Reimer, McLachlan & Webb 1992). On land, the body slides along the ground. Two gaits are used when on land: hatchlings and large *Ca. caretta*, *E. imbricata* and *L. olivacea* use a quadrupedal walking gait. A breast-stroke-like gait in which the two front flippers push together, aided in part by the hind flippers, is used by large *Ch. mydas* and *N. depressus* (Bustard 1972).

Feeding and Digestive System

Hatchlings of all genera commence life as carnivores feeding on surface zooplankton. As youngsters they change to a benthic feeding lifestyle. Diet varies among the genera, and the jaws and keratinised sheaths are specialised to cope with their respective diets. The jaws of *Ca. caretta* and *L. olivacea* form large crushing plates with associated powerful muscles for breaking hard-bodied molluscs and crustaceans (Dodd 1988; Marquez 1976; Moodie 1979). *Eretmochelys imbricata* has pointed, sharp-edged jaws for prying sponges out of crevices (Meylan 1985). As an adult, *Ch. mydas* is almost totally herbivorous and uses its serrated jaws for cropping algae, sea grass and mangroves (Lanyon, Limpus & Marsh 1989). Thomson (1980) has described the anatomy and histology of the digestive tract of *Ch. mydas* and *Ca. caretta*. Adaptations for herbivory in *Ch. mydas* include a large crop, stomach and colon, larger than those of the carnivorous *Ca. caretta*, and a functional caecum. *Chelonia mydas* depends on a rich cellulolytic microflora (bacteria) and microfauna (protozoa) in the caecum and colon for fibre digestion (Fenchel, McRoy, Ogden, Parker & Rainey 1979), and it can digest cellulose as efficiently as ruminants and dugong. However, in *Ch. mydas* the low digestibility of protein in sea grass probably is a result of most cell wall digestion occurring in the hind gut (Bjorndal 1979, 1980). Wood (1974) identified nine, possibly ten, essential amino acids required in the diet of young *Ch. mydas*. While this is significant for preparation of artificial diets, it may not be significant for diets containing natural proteins.

Circulatory, Respiratory and Excretory Systems

The anatomy of the circulatory system of cheloniid turtles has been neglected (for example, *Ca. caretta*, Dodd 1988), but is assumed to resemble that of other chelonians (Jackson 1979). In an assay of 27 blood chemistry properties and packed cell volume (PCV) for wild *Ch. mydas* only levels of uric acid and cholesterol differed between the sexes. Thirteen blood properties were correlated to turtle size and PCV was independent of sex and size of the turtles (Bolten & Bjorndal 1992). Blood chemistry and morphology for *Ca. caretta* has been reviewed by Dodd (1988). The lungs of *Ca. caretta* are comparable to those of marine mammals and are adapted to prolonged diving and a high metabolic activity (by reptilian standards). There is a wide intrapulmonary bronchus with complete cartilage rings, cartilage in the large trabeculae of the tubular chambers, well-vascularised, alveolus-like structures, and a partial single capillary net and well-developed pulmonary musculature (Perry, Darian-Smith, Alston, Limpus & Maloney 1989). *Caretta caretta* can dive to 233 m with breath-holds up to 21 minutes (Sakamoto, Uchida, Naito, Kureha, Tujimura

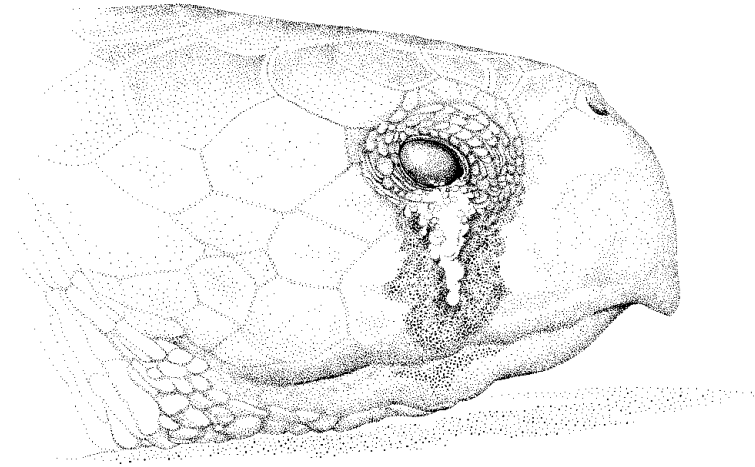


Figure 19.2 Secretion of surplus salt from the eye of *Caretta caretta*. The lachrymal gland is the primary osmoregulatory organ in marine turtles. (After photo by J.P. Ferrero/Auscape International) [T. Wright]

& Sato 1990) to avoid turbulent surface waters. The kidney in *Ch. mydas* is predominantly ammonotelic as would be expected for an aquatic species (Khalil 1947), but it does not contribute significantly to electrolyte/water balance. The latter is the function of the lachrymal salt gland which is functional from the time the hatchling leaves the nest. Young *Ch. mydas* have the highest Na^+ secretion rate for any reptile and a secretion rate similar to that of many marine birds. Hatchlings are capable of excreting the Na^+ content of approximately 0.2 to 0.5 ml of sea water per hour with osmotic concentrations of lachrymal gland tears 1.5 to 2.0 times that of sea water (Marshall & Cooper 1988). These glands enable *Ca. caretta* and *Ch. mydas* to maintain plasma homeostasis without access to fresh water (Bennett, Taplin & Grigg 1986; Marshall & Cooper 1988).

Cheloniid turtles secrete high-molecular-weight, water-soluble proteins from the inguinal and axillary (Rathke's) glands, but not all genera secrete lipids. The function of these secretions is not known (Mason 1992).

Thermoregulation

Cheloniid turtles are only able to maintain their deep body temperature to within about 3°C above the ambient water temperature (Mrosovsky & Pritchard 1971) and do not have a thermoregulatory capacity comparable to that of the Dermochelyidae (see Chapter 20). While some heat may be obtained through the dark dorsal surface during basking, body heat can be also generated via muscular activity. The pectoral muscle in actively swimming adult *Ch. mydas* is about 7°C warmer than in inactive turtles (Standora, Spotila & Foley 1982). Thermal inertia resulting from large body size can contribute to slow cooling rates during deep dives into cold water, while increased cooling rates can be achieved by flushing the stomach with cold water, if required (Sakamoto *et al.* 1990).

Sense Organs and Nervous System

Cheloniid turtles have an acute sense of smell (but not taste) that can operate underwater. The functioning of the olfactory epithelium of the nasal passages can be blocked by Zn^{++} ions (Manton 1979). In the sea, cheloniids are constantly sampling their surroundings by flushing water from the buccal cavity

into the nasal cavities and out through the nostrils. The anatomy of chemical reception in chelonians was reviewed by Scott (1979). The role of chemoreception in the life of the marine turtle remains unclear.

The eyes of cheloniid turtles are well developed and conform to the general chelonian eye, in which cones predominate in the retina, but the lens is more strongly curved (Granda 1979). The colour vision of *Ch. mydas* extends at least from near-ultraviolet to green (360 to 500 nm), while that of *Ca. caretta* extends minimally from near-ultraviolet to red (360 to 700 nm) (Witherington & Bjorndal 1991a). *Chelonia mydas* has a greater spectral sensitivity for shorter wavelengths than *Pseudemys scripta*, with spectral sensitivity peaking at 520 nm and secondary peaks at 600 nm and 450 to 460 nm (Granda 1979).

Endocrine and Exocrine Systems

Hormones appear to play an important role in facilitating specific physiological events during spermatogenesis, vitellogenesis, migration, ovulation and oviposition. Adult male *Ca. caretta* exhibit a prenuptial spermatogenic cycle that coincides with increased concentrations of serum testosterone. Levels of testosterone remain high during migration to the breeding area and mating (Wibbels, Owens, Limpus, Reed & Amoss 1990). Four to six weeks before adult female *Ca. caretta* migrate, a significant rise occurs in serum oestradiol-17 β (E₂) concentration, which decreases towards and during migration. Serum testosterone levels also increase in the months before migration. Concentrations of E₂, serum testosterone and serum progesterone are high at oviposition for each of the successive clutches laid during the breeding season, except for the last clutch of the season when they are low (Wibbels *et al.* 1990).

Surges in serum concentrations of follicle stimulating hormone, luteinising hormone and progesterone occur in *Ca. caretta* and *Ch. mydas* within 20 to 50 hours, following oviposition. Concentrations of serum testosterone decline and fluctuations in oestradiol are low or not detectable in the same period (Wibbels, Owens, Licht, Limpus, Reed & Amoss 1992). Similar surges occur in luteinising hormone and progesterone during the ovulatory and nesting cycle of *L. olivacea* (Licht, Owens, Clifton & Penaflores 1982). The function of follicle stimulating hormone and luteinising hormone in turtles may be different from their function in mammals (Licht 1980).

Prostaglandins have an active role in nesting behaviour and ovulation in *Ca. caretta*. Prostaglandin PGF_{2 α} apparently stimulates oviducal contractions to expel eggs, while PGE₂ may be more important in promoting cervical relaxation (Guillette, Bjorndal, Bolten, Gross, Palmer, Witherington & Matter 1991). Owens (1980) and Licht (1980) provide detailed reviews of marine turtle endocrinology.

Reproduction

Age at sexual maturity for eastern Australian cheloniids is probably about 30 to 50 years (Limpus & Walter 1980; Limpus 1991, 1992).

The adult female has massive, paired ovaries, which produce mature ovarian follicles >2.5 cm in diameter. The oviducts are up to 6 m long (Deraniyagala 1939; Owens 1980; Limpus 1985). Copulation usually occurs before the first ovulation for the season. A female may mate with a series of males and stores sperm in the oviducts for use later in the breeding season (Owens 1980; Limpus, Fleay & Guinea 1984a; Limpus 1993). Cheloniids produce white, spherical eggs that average 35 to 55 mm in diameter (depending on the genus), with flexible calcareous shells (Miller 1985). Individual females normally do not breed in successive years (Hirth 1980; Limpus, Fleay & Baker 1984b; Limpus 1985). The egg laying period may be distinctly seasonal (summer in eastern and

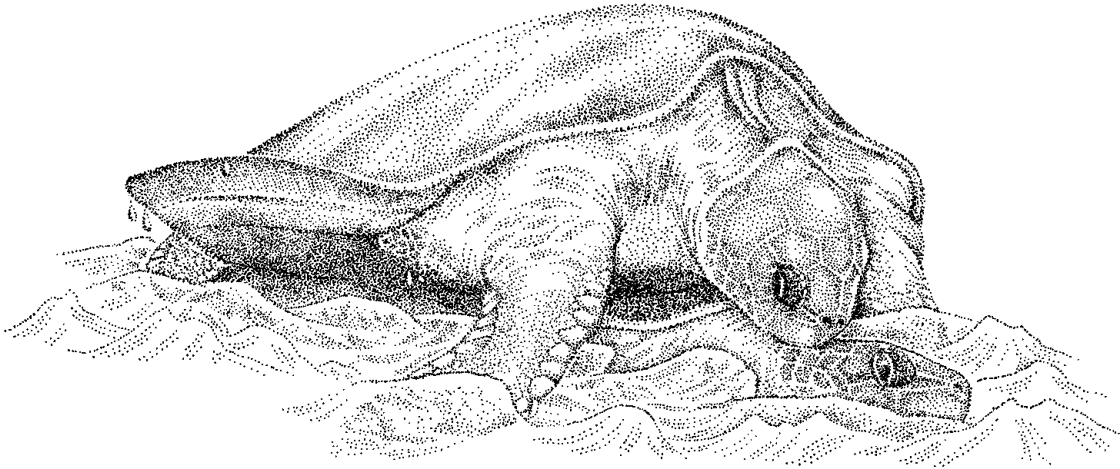


Figure 19.3 Mating in *Natator depressus*.

[K. Couper]

western Australia), or all year round with a dry season peak in activity, as occurs across northern Australia (Cogger & Lindner 1969; Limpus 1971a; Bustard 1972). Within a breeding season females lay one to 11 clutches, containing on average 50 to 132 eggs, at about two weekly intervals. Nests are 43 to 70 cm deep, depending on the species, and are dug in the supratidal, frontal sand-dunes (Hirth 1980; Limpus 1971a; Limpus, Miller, Baker & McLachlan 1983a). Hatchlings emerge from nests approximately two months after the eggs are laid (Miller 1985). Hatchlings of a single clutch may have different fathers as a result of fertilisation by sperm from several males having been stored in the oviducts (Harry & Briscoe 1988).

Male *Ca. caretta* appear to be annual breeders, but this may not apply for other genera (Wibbels *et al.* 1990; Limpus 1993). Testes are abdominal and a single grooved penis is erectile from within the cloaca.

Embryology and Development

The cleidoic eggs of cheloniids follow typical turtle embryological development. At oviposition the embryos are at middle gastrulation (Stage 6, Miller 1985). For successful incubation, they must be laid in well ventilated, low salinity, high humidity nest substrate, which is not subjected to flooding (Ackerman 1980; Miller 1985; Maloney, Darian-Smith, Takahashi & Limpus 1990). Embryos can be killed by rotation of the eggs during incubation (Limpus, Baker & Miller 1979; Parmenter 1980).

Nest temperature, which may range from 25° to 33°C, determines the length of the incubation period, of approximately 6 to 13 weeks (Miller 1985). The sex of hatchlings is a function of nest temperature during middle incubation (Miller & Limpus 1981; Yntema & Mrosovsky 1980, 1982; McCoy, Vogt & Censky 1983). The theoretical temperature that produces a 1:1 sex ratio with constant temperature incubation (pivotal temperature), varies between species and breeding units. For eastern Australian *Ca. caretta*, the pivotal temperature is 28.6°C (Limpus, Reed & Miller 1983b; Limpus 1985). Two heterogeneous nuclear ribonucleoprotein particles that are differentially expressed in male and female embryonic urinogenital systems at different incubation temperatures are implicated in sexual differentiation of *Ca. caretta* (Harry, Williams & Briscoe 1990).

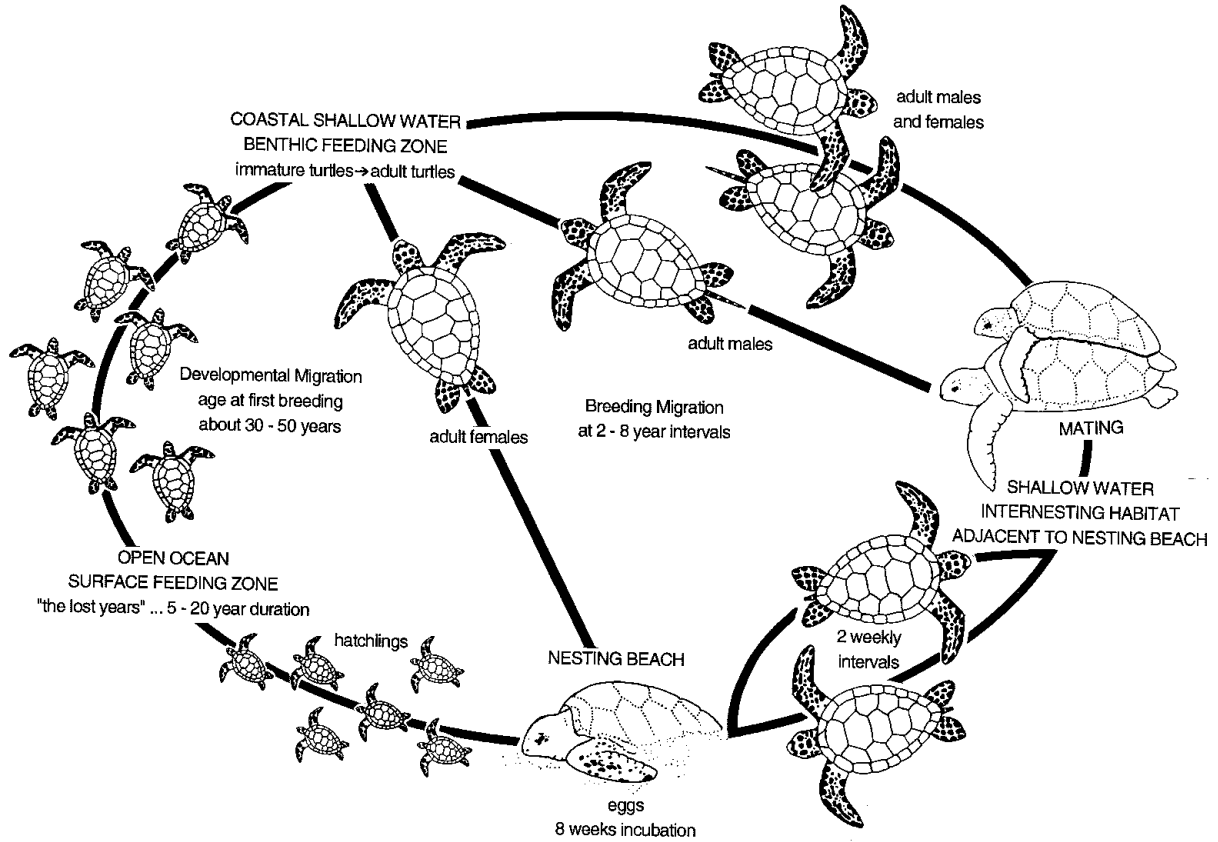


Figure 19.4 Generalised life cycle for a marine turtle. (After Lanyon, Limpus & Marsh 1989) [D. Wahl]

NATURAL HISTORY

Life History

After they emerge from the nest, hatchlings swim out to sea where they are dispersed by currents into the open ocean (Carr 1986). Post-hatchlings of *N. depressus* are exceptions, as they are entrained over the Australian continental shelf (Walker & Parmenter 1990). During this post-hatchling, planktonic phase, the juveniles are believed to feed on macrozooplankton at the surface convergence lines. After several years and one or more circuits of the ocean gyre, the young of most species select a feeding area within continental shelf waters and change to benthic feeding when they are approximately 300 to 400 mm in carapace length or greater, depending on the species (Fig. 19.4; Carr 1986).

The distribution and biology of post-hatchlings in Australian waters is poorly understood. An immature turtle remains associated with the same continental shelf or inshore feeding area for years. However, it may make one or more shifts in feeding site before selecting the feeding area it occupies as an adult (Limpus 1982, 1985; Limpus & Reed 1985a). In the tropics, at least, an adult associates with the one feeding area, possibly for life, which it leaves only during its breeding migrations (Limpus 1989; Limpus & Reimer 1992; Limpus *et al.* 1992). Turtles migrate from widely scattered feeding areas to breeding areas.

The slow growth to maturity is reflected in the large proportion of the total population that is immature. Sex ratios are variable and often significantly biased towards females (Limpus 1985, 1992; Limpus & Reed 1985a, 1985b; Wibbels, Martin, Owens & Amoss 1991). Reliable predictive population models are scarce because of difficulties in estimating the age of individuals and the survivorship of cohorts over the vast feeding areas of a single population. It appears that large immature and adult *Ca. caretta* require a high annual survivorship and a long breeding life to maintain population stability (Frazer 1983; Crouse, Crowder & Caswell 1987).

Ecology

Most ecological studies of marine turtles have been conducted on the nesting beaches. Conversely, there have been few ecological studies of marine turtles in their aquatic habitats. *Chelonia mydas* principally inhabits areas with abundant seagrass and algae, especially coral reefs, rocky reefs and seagrass flats, and it appears to have a positive feed-back effect on the seagrass community. As a result of the hind gut digestion of fibre and the incomplete removal of nutrients, especially nitrogen, during the passage of seagrass through the gut, the turtle returns to the environment a coarsely cut and partly digested faecal product with a C:N nutritional quality that is superior to the original seagrass (Thayer, Engel & Bjorndal 1982). Thus the turtle increases the rate of movement of nitrogen and other elements through the food web of sea grass beds. On the other hand, the migrating female transports substantial quantities of nutrients from the feeding areas in the form of mature follicles which she deposits as eggs at the rookeries. Some of these nutrients then enter the food web at the rookeries as decaying eggs on the beach, and as eggs and hatchlings eaten by predators (Lanyon *et al.* 1989). While slow growth, delayed sexual maturity and long intervals between breeding seasons of wild *Ch. mydas* are probably under nutritional control rather than genetic control (Bjorndal 1980, 1985), they may also be characteristic of the family (Lanyon *et al.* 1989). Limpus & Nicholls (1988) have demonstrated that regional climatic events, such as the El Niño southern oscillation (ENSO), determine the proportion of adult female *Ch. mydas* available to breed in any one year, and hence presumably the timing between breeding seasons. A similar ENSO effect has not been detected in the other genera.

Within Australia the other species are associated with different foraging habitats. *Caretta caretta* is most frequently found in shallow bays and reefs with abundant molluscs and crabs. *Lepidochelys olivacea* seems to be associated with soft-bottom habitats which are deeper than those used by *Ca. caretta*, and *E. imbricata* is mostly associated with hard-bottomed habitats. *Natator depressus* occurs in similar soft-bottomed habitats to *L. olivacea* (Limpus 1975a; Limpus *et al.* 1984b; Limpus 1985, 1992).

Nesting marine turtles can have some negative impacts on strand vegetation communities (Rogers 1989). However, while nesting they bury nutrients (eggs, humus, vegetation) and seeds back into the soil. In loose coralline sand, the grass and tree roots enhance the ease with which a nesting turtle can construct an egg chamber and hence deposit her eggs (Bustard & Greenham 1968). Regularly nesting under trees, however, could be a disadvantage to the turtle population in providing relatively cooler sand and thus affecting the sex ratio. The warm, brown sand beaches of mainland eastern Australia produce mostly female hatchlings of *Ca. caretta*, and the cooler, white sand beaches of the adjacent coral cays and shaded habitats produce mostly males (Limpus, Reed & Miller 1983b; Limpus, Reed & Miller 1985). In the southern Great Barrier Reef, *Ch. mydas* clutches laid on the northern, sunny side of islands produce mostly female hatchlings and the clutches on the southern shaded areas produce mostly males (Limpus *et al.* 1983b; Limpus *et al.* 1984a).

Behaviour

The hatchling is imprinted by the earth's magnetic field at the nesting beach as it leaves the nest (Lohmann 1991). Imprinting to the smell of the nest substrate or to the water that the hatchling first contacts may also occur (Grassman, Owens, McVey & Marquez 1984). Genetic studies provide convincing evidence that the breeding adult does return to the region of birth (Gyuris & Limpus 1988; Bowen, Meylan, Ross, Limpus, Balazs & Avis 1992; Karl, Bowen & Avise 1992). It remains to be demonstrated however, whether this fidelity is the result of imprinting to the natal beach during the egg or hatchling phase, or whether the hatchling is imprinted to the general region of her birth and subsequently imprinted to the specific rookery as an adult during the first breeding season (Limpus *et al.* 1992).

The hatchling does not feed or sleep between leaving the nest and moving into deep, offshore water. Hatchlings orient to low elevation light horizons when moving from the nest to the sea (Limpus 1971b; Salmon, Wyneken, Fritz & Lucas 1992). They can be disoriented by bright lights, although not by the yellow wave lengths of low pressure sodium vapour lights (Mrosovsky & Shettleworth 1975; Witherington & Bjorndal 1991b). By swimming perpendicular to wave fronts, the hatchlings are directed to swim out to the open ocean (Salmon & Lohmann 1989).

Each adult female migrates faithfully between its particular feeding area and rookery, although different paths are followed on their breeding migrations. While some migrate in excess of 2600 km, most migrate less than 1000 km to their rookeries. Recaptures of females tagged at the south-eastern Queensland rookeries have been recorded from Indonesia, Papua New Guinea, Solomon Islands, New Caledonia, Fiji, and in Australia, Northern Territory, Queensland and New South Wales (Limpus *et al.* 1992). *Natator depressus* does not migrate beyond the Australian continental shelf (Limpus, Parmenter, Baker & Fleay 1983c). Adult females display a high degree of fidelity to their chosen nesting beach, with most females returning to the same small beach for their successive clutches within a breeding season and in successive breeding seasons (Carr, Carr & Meylan 1978; Limpus 1985; Limpus *et al.* 1984a; Limpus *et al.* 1984b; Limpus 1992).

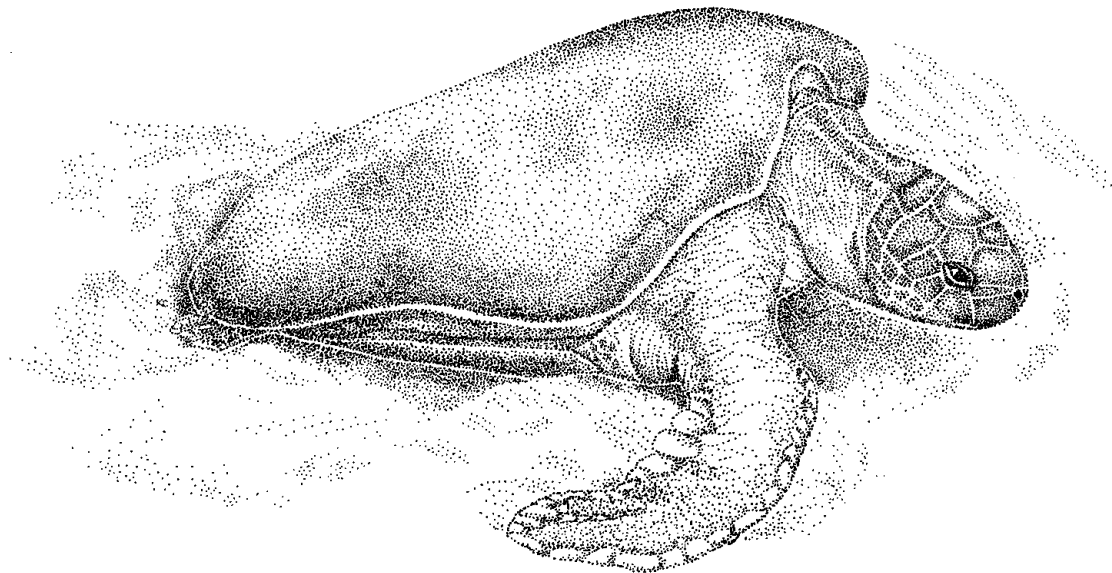


Figure 19.5 Female *Natator depressus* nesting.

[K. Couper]

The Cheloniidae and the Dermochelyidae display remarkably similar nesting behaviours. The female selects a nest site above the tide level and clears the loose sand by excavating a body pit with the front and rear flippers; below the body pit she digs a vertical sided, flask-shaped egg chamber with the hind flippers; she lays the eggs in the egg chamber and then conceals them with sand using first her rear flippers, then all four flippers (Fig. 19.5; Bustard & Greenham 1969; Bustard, Greenham & Limpus 1971; Pritchard 1971).

Economic Significance

Harvests of eggs and turtles have been reviewed by Parsons (1962, 1972), Marquez (1976), Milliken & Tokunaga (1987) and Groombridge & Luxmoore (1989). Wherever there has been human contact with cheloniid turtles they have been harvested for food (either as eggs or the turtles for meat), oil, skin for leather and scale for tortoiseshell or bone: *Ch. mydas* in particular has been eaten as meat and in soup; *E. imbricata* has been harvested for tortoiseshell (=bekko in Japanese); *L. olivacea* has been taken for leather. Overharvest of most populations for extended periods has caused significant global declines in marine turtle numbers and there is now an embargo on international trade in marine turtle products under the Convention for International Trade in Endangered Species (see Chapter 14). Significant internal trade in *Ch. mydas* and *E. imbricata* occurs in Papua New Guinea, Indonesia and Cuba, while commercial egg harvesting is common in Indonesia and South-East Asia. With increasing interest in ecotourism, sea turtle rookeries have potential use as a non-harvested commercial resource. Ecotourism is established at Australian nesting sites (Bundaberg and Heron Island in the southern Great Barrier Reef), and draws more than 35 000 visitors each summer, and in South Africa (Hughes pers. comm.).

BIOGEOGRAPHY AND PHYLOGENY

Distribution

All cheloniid genera except *Natator* have a worldwide distribution in tropical and temperate waters. The feeding distribution of *N. depressus* is confined almost totally to the Australian continental shelf, and nesting is confined to Australian territory. All five species are present in northern Australian waters, but the major rookeries are more restricted in distribution (Fig. 19.6; Limpus 1982, 1985; Miller & Limpus 1991; Limpus *et al.* 1988). *Caretta caretta* nests in the Capricorn-Bunker Groups and adjacent Bundaberg mainland in the southern Great Barrier Reef, and on Murion Island on the southern North West Shelf. *Chelonia mydas* nests in the Capricorn-Bunker Groups of the southern Great Barrier Reef, on Raine Island and Moulter Cay and associated islands of the outer northern Great Barrier Reef, on the Wellesley Group in the Gulf of Carpentaria, and on the Lacepede Islands, Monte Bello Islands and Barrow Island in northern Western Australia. *Eretmochelys imbricata* nests in the northern Great Barrier Reef and Torres Strait, on Truant Island in north east Arnhem Land, and on Rosemary Island on the North West Shelf. *Lepidochelys olivacea* nests in the McCluer Island Group of western Arnhem Land. *Natator depressus* nests in the Peak and Wild Duck Islands in inshore southern Great Barrier Reef, on Crab Island and Deliverance Island of the northeast Gulf of Carpentaria and western Torres Strait, in the Sir Edward Pellew Group in the Gulf of Carpentaria, on Cobourg Peninsula and Greenhill Island in western Arnhem Land, and on Delambre Island on the North West Shelf.

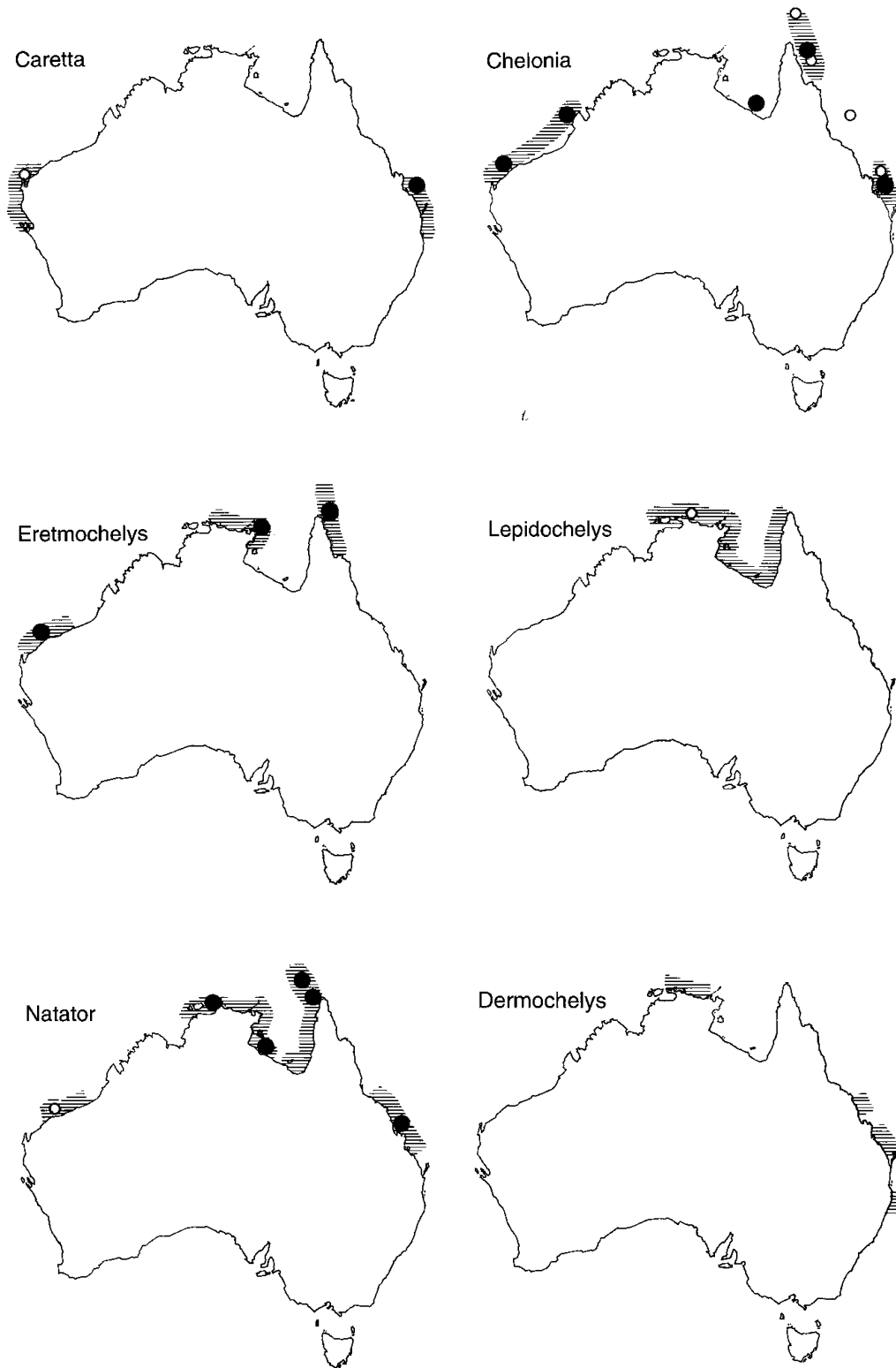


Figure 19.6 The primary breeding areas of the cheloniids *Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys olivacea*, *Natator depressus*, and for *Dermochelys coriacea*. Shading indicates the primary breeding areas: major nesting colonies (>1000 females/year) and minor colonies (hundreds of females/year) are indicated by closed and open circles, respectively. [W. Mumford]

The widely spaced breeding concentrations for each species should be managed as separate stocks because there is little potential for recolonisation of depleted populations from other distant breeding concentrations (Bowen *et al.* 1992; Karl *et al.* 1992).

Affinities with other Groups and Fossil Record

The Cheloniidae is one of six families of marine turtles known from the fossil record. Four families have been recorded in Australia, including the Dermochelyidae, and the extinct Desmatochelyidae (*Cratochelone*, *Notochelone*) and Protostegidae (Pritchard & Trebbaum 1984; Gaffney 1991). Of the 31 genera attributed to Cheloniidae, only five are extant—the monospecific *Caretta*, *Chelonia*, *Eretmochelys* and *Natator*, and *Lepidochelys*, which includes two species. All five genera are represented in Australia (Pritchard & Trebbaum 1984).