Reach for this book whenever a sick or injured tortoise comes into the surgery.

Essentials of Tortoise Medicine and Surgery is designed as a concise and practical quick reference for the busy practitioner seeing chelonians as part of their caseload. Covering everything from species identification to common basic surgery for tortoises and freshwater turtles, the emphasis is on the more common and likely diagnoses.

The first part of the book gives an overview of the basics of tortoise and semi-aquatic/aquatic freshwater turtle husbandry and keeping, as well as a guide to general investigation and diagnostic techniques open to clinicians. The second part provides a clinical guide based on clinical signs and differential diagnoses.

Based upon the experience of authors who have been practicing with these species for several decades, this book is a useful guide to veterinarians, students, veterinary nurses and technicians new to working with these fascinating creatures. It will also serve as a useful aide-memoire to more experienced clinicians.

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John Chitty • Aidan Raftery
# Preface

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This book is designed to be a practical help for busy clinicians seeing Chelonia as part of their caseload.

It is not intended to be a complete textbook of tortoise diseases – for this, readers are referred to McArthur, Wilkinson and Meyer’s *Medicine and Surgery of Tortoises and Turtles* (Blackwell Publishing, Oxford, 2004). More, it is intended to assist the clinician inexperienced with these species as a practical guide to assist in investigation of these occasionally seen species: hence its emphasis on the more common/likely diagnoses rather than completeness. It is based on our joint experiences in practising with these species over several decades. The species too are biased towards those more commonly seen in UK and US practices, rather than a complete overview of chelonid diseases.

To assist in this, the book may be considered in two parts – the first gives an overview of the basics of tortoise and semi-aquatic/aquatic freshwater turtle husbandry and keeping, as well as a guide to the general investigation and diagnostic techniques open to clinicians.

The second part is based on differential diagnosis and investigation by clinical signs. This does result in some repetition between sections, though we trust this will be balanced by an ease in following through a particular clinical sign! Disease syndromes and infectious agents are discussed within these sections, as patients tend to present with signs rather than diagnostic labels! A few exceptions are made for more complex syndromes that require more explanation or that are referenced from many different clinical signs; for example, hepatic lipidosis and follicular stasis.

In summary, we hope that this book will provide a useful guide and summary for the inexperienced and helping hand for those students, technicians/nurses and clinicians wishing to start advancing their knowledge of chelonian medicine. For more experienced clinicians and technicians working with these species, we hope that it will provide a useful aide memoire.

We would like to thank our colleagues and the owners of our patients for much assistance over many years. We would also like to thank the team at Wiley Blackwell for all their help and assistance during the long writing period. Most of all, we would like to thank our families for help, support and forbearance of long-term absenteeism!

John Chitty and Aidan Raftery
1
Biology

1.1 Species and Family Overview

This first section provides details on how to identify the different species described in this book.

Below is a brief description of the present-day families. The classification of species (and hence their scientific names) changes as we learn more about how closely they are related to other species. Most texts quickly become out of date as the taxonomists and systematists learn more about the relationship between and within different species. For an in-depth description with identification keys, the reader is directed to specialist publications such as Ernst and Barbour’s Turtles of the World and Ferri’s Turtles and Tortoises, which are good texts that provide more detailed information (see Figures 1.4.1 and 1.4.2 for scute nomenclature).

Cheloniidae The six species of hard-shelled Sea turtles.

Carettochelyidae This family has only one living species, the Pig-nosed turtle. The forelimbs are modified as flippers. It has a pig-like snout, and a smooth carapace from which scutes are absent.

Dermochelyidae There is only one species in this family, the Leatherback sea turtle.

Trionychidae There are approximately 22 species in this family of semi-aquatic turtles, which comprises the soft-shell turtles. The shell is reduced and incomplete. The carapace is leathery and pliable, particularly at the sides. They have elongated, soft, snorkel-like nostrils. Their necks are disproportionately long in comparison to their bodies.

Kinosternidae Approximately 22 species are recognised in this family, which consists of the Mud turtles and the Musk turtles. Usually, one or two plastral hinges present.
They have less than 12 plastron scutes. Some degree of toe webbing is present. They are small- to medium-sized semi-aquatic turtles.

**Dermatemydidae**  There is one species, the Central American River turtle, which is almost totally aquatic. Inframarginal scutes are present.

**Platysternidae**  There is one species, the Big-headed turtle. The head is so big that it cannot be withdrawn into the shell. Inframarginal scutes are present.

**Chelydridae**  There are four living species, the Alligator snapping turtle and three species of Snapping turtles. These are very aggressive turtles, with powerful jaws. Inframarginal scutes are present. There is a long tail. The rough carapace is keeled and strongly serrated posteriorly. The plastron is reduced and hingeless.

**Testudinidae**  There are approximately 50 living species. This is the most common family presented for veterinary treatment in Europe. The hind limbs are columnar. Inframarginal scutes are absent. There are two phalangeal bones in the digits of the hind feet. There is no webbing of the toes. The genus *Kinixys* are the only tortoises with a hinge of the carapace. If a plastron hinge is present between the femoral and abdominal scutes, then this is in the genus *Testudo*, with the exception of *Testudo horsfieldi* (Horsfield’s tortoise), which is recognisable by the horny claw on the end of its tail and by having only four claws on each forefoot. If the hinge is between the humeral and pectoral scutes, then this is *Pyxis arachnoides*, the Malagasy Spider tortoise. If the plastron is rigid with a very flat and flexible carapace, then this is *Malacochersus*, the Pancake tortoise. These are tortoises with paired gulars that project anteriorly beyond the carapace rim, especially in males and in the genus *Gopherus*, the Gopher tortoises. Where the supracaudal scute is undivided, then the tortoise is of the genus *Geocheleone*.

**Guide to identification to the genera of the Testudinidae**

**Kinixys**  This genus contains six species. They are the only tortoises with a movable hinge in the carapace. Three species are seen relatively commonly. In *Kinixys homeana* (Home’s hinge-back tortoise), the posterior portion of the carapace is strongly inverted from the level of the anterior end of the fifth vertebral scute. The inversion of the carapace starts at the middle of the fifth vertebral scute in *K. erosa* (the Serrated hinge-back tortoise) and *K. belliana* (Bell’s hinge-back tortoise). The posterior rim of the carapace of *K. erosa* is strongly serrated, while the same area of *K. belliana* is not serrated, or only weakly serrated.

**Acinixys**  This genus contains one species: *Acinixys planicauda*, the Madagascar Flat-shelled spider tortoise. The tail is flattened and its dorsal surface is covered with enlarged scales. There is a slight medial ridge on the maxillae. The plastron is hingeless. The gulars are paired, thickened and extend slightly beyond the rim of the carapace.

**Pyxis**  This genus contains one species: *Pyxis arachnoides*, the Malagasy Spider tortoise. The plastron has a hinge between the humeral and pectoral scutes.
**Chersina** This genus contains one species: *Chersina angulate*, the South African Bowsprit tortoise. The plastron is hingeless. There is a single gular scute that projects anteriorly. The anal scute is large in contrast to the other species with a single projecting gular scute, *Geochelone yniphora*.

**Homopus** This genus contains five small species of tortoise. The plastron is hingeless. The gulars are paired, and broader than they are long.

**Psammobates** This genus contains three species. These colourfully patterned small tortoises are known as South African Star tortoises. The plastron is hingeless. The gulars are paired and broader than they are long. The carapace is domed, with ascending sides.

**Manouria** This genus contains two species: *Manouria emys*, the Asian Brown tortoise, with two recognised subspecies; and *Manouria impressa*, the Impressed tortoise. The plastron is hingeless. The forefoot has five claws. The supracaudal scute is subdivided into two. Large black blotches occur on the marginal.

**Indotestudo** This genus contains two species of medium-sized tortoises: *Indotestudo elongata*, the Elongated tortoise; and *Indotestudo forsteni*, the Travancore tortoise. The plastron is hingeless. The forefoot has five claws. The supracaudal scute is subdivided into two. There is a long terminal tail scale. They are a light cream–yellow colour, with brownish blotches on the carapace and to a lesser extent on the plastron. They have a short trachea, which is significant when intubating.

**Geochelone** This is the largest genus, containing 21 species. All species within this genus are relatively large when adult. The plastron is hingeless. This genus includes the commonly kept species *Geochelone sulcata* (the African Spurred tortoise), *G. pardalis* (the Leopard tortoise) and *G. carbonaria* (the Red-footed tortoise).

**Testudo** This genus contains six or seven species, depending on whether *Testudo weissingeri* is classified as a species or a subspecies. They all have club-like fore and hind feet. All also have five claws on the forefeet, except for *Testudo borsfieldi*, which has four. The gular scutes are paired, but not projecting beyond the carapacial rim.

- The hinge in the plastron is between the femoral and the abdominal scutes, with the exception of *Testudo borsfieldi*, which lacks the movable hinge.
- *Testudo hermanni* can be distinguished from the others of the genus by having a horny spur on the end of its tail: there are no enlarged tubercles on the thigh and the supracaudal scute is usually divided.
- *Testudo graeca* has an enlarged tubercle on the thigh, the supracaudal scute is undivided and there is no horny terminal tip to the tail. It is important to distinguish the Tunisian tortoise, *Furculachelys nabeulensis*, from *Testudo graeca*. Until recently, it was classified as a subspecies of *T. graeca* due to similarities.
Unlike *T. graeca*, this species does not hibernate. The key differences from *T. graeca* are as follows: the supracaudal scute is curled; they are very small, with adults rarely exceeding 16.5 cm carapace length; and the carapace is light yellow in colour, with strong black markings in the scute centres. They are brightly coloured: the scutes have a black edging and a black spot in the centre, and there is a distinct yellow spot on the head, between the eyes.

- *Testudo iberia* has a flatter and broader carapace than *T. graeca*. They grow much larger and are often paler in colour, although darker populations do occur. The first vertebral scute is more angular in *T. iberia* compared to the more rounded shape in *T. graeca*.

- In *Testudo marginata*, the supracaudal and the posterior marginal are greatly flared (see Figure 1.1.1). There are four or five longitudinal rows of enlarged scales on the anterior surface of the foreleg.

- *Testudo kleinmanni* is the smallest species (see Figure 1.1.2). There is no tubercle on the thigh, only the supracaudal scute is flared and there are usually only three longitudinal rows of enlarged scales on the anterior surface of the foreleg.

- *Testudo weissingeri* was originally considered a dwarf population of *T. marginata*. They have similar identifying features; however, they are much smaller. They can usually be distinguished from *T. marginata* by the carapace coloration, which is dull brown or blackish, with greyish-yellow or horn-coloured patches flecked with grey. This compares with a more contrasting pattern of a pale yellow on black seen with *T. marginata*.

**Gopherus** This genus contains four species of tortoises from North America. Their forelimbs are flattened as an adaptation for burrowing. The carapace is
flattened and lacks a cervical indentation (see Figure 1.1.3). The plastron is hingeless. They all have paired gular scutes that project anteriorly, especially in males. This genus includes the Gopher tortoise (*Gopherus polyphemus*), which is often kept in North America.

**Malacochersus**  This genus contains one species: *Malacocherus tornieri*, the African Pancake tortoise. The carapace is flattened and flexible. The juvenile carapacial fenestra are retained into adulthood. This allows this species to take refuge in narrow cracks. The plastron is hingeless.
Emydidae  These are mainly found in North America. They can be divided between the Box turtles of the genus *Terrapene*, where the anterior and posterior portions of the plastron close completely, and Pond turtles, known in some parts of the world as terrapins, where there is no hinge. The family also includes *Emys orbicularis*, the European Pond turtle, and *Emydoidea blandingii*, Blanding’s turtle, where a hinge is present, although in the adult it does not close completely. Inframarginal scutes are absent. There are three or more phalangeal bones in digits 2 and 3 of the hind feet. There is usually some degree of webbing. *Deirochelys reticularia*, the chicken turtle, is recognisable because of its long neck: if measured from shoulder to snout, its length is approximately equal to that of the plastron. *Trachemys scripta elegans*, the Red-eared slider, is instantly identified by the typical reddish marks on the side of its head, often accompanied by a red spot on top of its head. This species is captive farmed in large numbers for the pet trade.

Geoemydidae  This is a diverse family of turtles, with about 70 species. It includes the Asian Pond and River turtles, and the Asian Box turtles and other turtles.

Pelomedusidae and Chelidae  These are the side-necked turtles. These semi-aquatic animals are carnivorous. Only the Chelidae have a nuchal scute.

**Further reading**

As with all exotic species kept in captivity, a good knowledge of the natural history of these animals is essential in order to understand their various needs in captivity, especially relating to husbandry, diet, reproduction and behaviour.

The following provides a brief guide to the main species that are kept as pets. As described in Chapter 1.1 and in the sources of information for this section (see below), there is some controversy in the classification and identification of these species. Therefore, some generalisations have been made within these descriptions.

**Testudo graeca (Mediterranean Spur-thighed Tortoise)**

There is much controversy over the classification of these tortoises. Fortunately, there is much in common between their basic diet and climate.

**Distribution**

*T. g. graeca*, found from northern Morocco to Libya, in southern Spain and in Sardinia/Sicily.

*T. g. terrestris*, found in southern Turkey, Syria, Lebanon, Jordan and from Israel to northern Egypt/Libya.

*T. g. zarudnyi*, found in Iran, Afghanistan and Pakistan.

**Habitat**

Arid areas from sea level to > 3000 m altitude.

**Hibernation**

High-altitude populations hibernate.

Smaller subspecies found at sea level tend not to – they are more likely to aestivate in hot weather. Because of the difficulties in identifying subspecies, smaller thinner individuals should not be hibernated.

**Diet**

Vegetative detritus: a wide variety of fibrous plants, especially their flowers.

**Reproductive data**

- Season: April to June (usually May/June).
- Eggs per clutch: 2–7.
● Laying site: 10 cm deep cavity.
● Incubation time: 3–4 months, although some reports suggest that eggs of *T. g. zarudnyi* may overwinter in the cooler parts of the range.

**Furculachelys naebulensis** (Tunisian Tortoise)

*Distribution*

Tunisia/western Libya.

*Habitat*

Sea level – arid areas.

*Hibernation*

Does not hibernate.

*Diet*

Vegetative detritus: a wide variety of fibrous plants, especially their flowers.

*Reproductive data*

● Season: April to June (usually May/June).
● Eggs per clutch: 2–7.
● Laying site: 10 cm deep cavity.
● Incubation time: 3–4 months.

**Testudo ibera** (Greek Spur-thighed Tortoise)

*Distribution*

North-east Greece, parts of the Balkans, the northern Aegean islands, and from parts of Turkey to Iran/Iraq.

*Habitat*

Arid areas from sea level to > 3000 m altitude.

*Hibernation*

From November to February.

*Diet*

Vegetative detritus: a wide variety of fibrous plants, especially their flowers. However, more omnivorous than *T. graeca*. Some individuals may consume molluscs and insects.

*Reproductive data*

● Season: April to June.
● Eggs per clutch: 6–7.
● Laying site: 10 cm deep cavity.
● Incubation time: 3–4 months.
**T. hermanni (Hermann’s Tortoise)**

*Distribution*
The western subspecies (*T. h. hermanni*) is found in north-eastern Spain, south-east France, western/southern Italy and Majorca, Minorca, Sardinia, Sicily and Corsica.
The eastern subspecies (*T. h. boettgeri*) is found in eastern Italy, the Balkans, Greece and western Turkey.

*Habitat*
Semi-open areas around forested regions.

*Hibernation*
Variable period between October and March.

*Diet*
More than 90% herbivorous – similar to *T. graeca*, but appears to favour legumes and clovers over grasses.
Will opportunistically eat worms, snails and carrion.

*Reproductive data*
- Season: mid-May to July.
- Eggs per clutch: 2–12.
- Laying site: 7–10 cm deep cavity.
- Incubation time: 90 days.

---

**T. horsfieldi (Horsfield’s Tortoise, aka Russian/Steppe/Afghan Tortoise)**

*Distribution*
South-eastern Russia, Iran, Afghanistan and Pakistan.

*Habitat*
Dry steppe up to 2500 m altitude.
Usually found near water.

*Hibernation*
Yes – can be > 6 months, as adapted to very hot summers and very cold winters.
Digs long, deep burrows to protect from weather extremes.
May aestivate in summer.

*Diet*
Vegetation – grasses, flowers and leaves.

*Reproductive data*
- Season: mating mid-March to end of April; females lay eggs in May/June.
- Eggs per clutch: 1–5 eggs per nest, in 1–4 nests.
- Laying site: excavated burrows.
- Incubation time: 100 days.
**T. marginata (Marginated Tortoise)**

*Distribution*
Greece, Sardinia.

*Habitat*
Dry scrub and woodland.
Hillsides.

*Hibernation*
Yes.

*Diet*
Herbivorous – grasses, flowers and some fruits.

*Reproductive data*
- Season: April to June; eggs laid June/July.
- Eggs per clutch: 3–11.
- Laying site: 10 cm deep excavations.
- Incubation time: 2–4 months, depending on soil temperature.

**T. kleinmanni (Kleinmann’s or Egyptian Tortoise)**

*Distribution*
Coastal Libya and Egypt; Israel.

*Habitat*
Desert and semi-desert scrub.

*Hibernation*
No – will aestivate in hot weather.

*Diet*
Mainly herbivorous – especially saltwort and sea lavender.
May take some insects and carrion.

*Reproductive data*
- Season: mating in autumn, with eggs laid in early spring.
- Eggs per clutch: 1 – very large; rarely up to 4.
- Laying site: buried in sand.
- Incubation time: 4–5 months.

**Geochelone sulcata (Sulcata or African Spurred Tortoise)**

*Distribution*
Sub-Saharan Africa – isolated populations from Mauritania (west) to Ethiopia/Eritrea (east).

*Habitat*
Arid acacia forest and woodland.
**Hibernation**
No – will spend dry season in burrows.

**Diet**
Any vegetation.
During the dry season may also take carrion and organic detritus.
Will store dry vegetation in burrows for feeding during the dry season.

**Reproductive data**
- Season: nest November to May.
- Eggs per clutch: 2–4 nestings per female, with up to 19 eggs per nest.
- Laying site: up to 40 cm deep nests.
- Incubation time: 120–210 days, depending on the timing of the rainy season.

**G. pardalis (Leopard Tortoise)**

See Figure 1.2.1.

**Distribution**
Eastern sub-Saharan Africa and southern Africa.

**Habitat**
Dry savannah, semi-desert, finbos.

**Hibernation**
No, but will hide in tunnels/burrows during cold periods at high altitude.

**Diet**
Mainly herbivorous – almost anything consumed.
Will also take carrion and excrement of other animals.

*Figure 1.2.1* The Leopard tortoise. Pyramiding may be seen in wild specimens, but is normally a consequence of abnormal growth in captivity.
Reproductive data
● Season: warm months – either May to June or October to November, depending on latitude.
● Eggs per clutch: up to 30 eggs each year, in up to six nests.
● Laying site: 10–30 cm deep in dry/stony soil.
● Incubation time: approximately 100 days, but up to 380 days reported.

**G. carbonaria** (Red-foot Tortoise)

*Distribution*
Northern South America.

*Habitat*
Open areas and dry forest.

*Hibernation*
No – aestivates in summer.

*Diet*
Mainly herbivorous – especially fallen fruit.
Will take carrion and invertebrates.

*Reproductive data*
● Season: June to September.
● Eggs per clutch: 2–15.
● Laying site: against trees, beside pathways in leaf litter or in soil.
● Incubation time: 3–6 months, depending on humidity and sunlight exposure.

**G. denticulata** (Yellow-foot Tortoise)

*Distribution*
Northern South America and Amazonian lowlands.

*Habitat*
Humid forest – lives under leaves.

*Hibernation*
No.

*Diet*
Insects, larvae and fallen fruit.

*Reproductive data*
● Season: throughout the year with several clutches per female – generally in drier seasons.
● Eggs per clutch: 1–12.
● Laying site: eggs laid on the ground.
● Incubation time: 4–5 months.
**G. elegans (Indian Star Tortoise)**

*Distribution*
Peninsular India and Sri Lanka.

*Habitat*
Tropical deciduous forest and dry savannah, but does need a supply of water.

*Hibernation*
No.

*Diet*
Herbivorous – especially fruits, vegetables and succulent leaves. Will eat carrion and insects.

*Reproductive data*
- Season: mates in rainy season; nests May to June and October.
- Eggs per clutch: 3–6 per clutch; up to four clutches per season.
- Laying site: 10–15 cm deep.
- Incubation time: approximately 120 days.

**Gopherus agassizii (Desert Tortoise)**

*Distribution*
Sonoran and Mojave Deserts in southern United States (USA)/northern Mexico.

*Habitat*

*Hibernation*
No, but aestivates for part of the summer.

*Diet*
Largely herbivorous – especially grasses and cacti. Will also eat carrion.

*Reproductive data*
- Season: nests May to July.
- Eggs per clutch: approximately 6.
- Laying site: 20 cm deep burrow in sandy soils.
- Incubation time: 3 months.

**Gopherus polyphemus (Gopher Tortoise)**

*Distribution*
Atlantic and Gulf Coastal plains of the USA.

*Habitat*
Well-drained sandy soil between grassland and woodland.
Hibernation
No.

Diet
Grasses, leaves, hard fruits, bones and insects.

Reproductive data
- Season: March to July.
- Eggs per clutch: approximately 7.
- Laying site: often buried close to parent’s burrow – approximately 15 cm deep.
- Incubation time: 80–110 days.

**Trachemys scripta elegans (Red-eared Slider, or Terrapin)**

*T. scripta scripta* may also be seen in captivity – its natural history is very similar to that of *T. s. elegans*.

**Distribution**
South-eastern USA, but has been introduced to many other areas, including the United Kingdom (UK).

**Habitat**
Calm water with a muddy bottom, abundant vegetation and basking sites.

**Hibernation**
Aestivates in summer.
Is capable of hibernation in cooler parts of its range.

**Diet**
Entirely carnivorous when young; older animals also take vegetation.

Reproductive data
- Season: courtship in spring/summer, in water; nests on land April to July.
- Eggs per clutch: 2–23.
- Laying site: buried in soil/sand.
- Incubation time: 60–80 days.

**Terrapene spp. (North American Box Turtles)**

*T. carolina* (Common box turtle) and *T. ornata* (Ornate box turtle) are most commonly seen in captivity.

**Distribution**
USA – the most common species (*T. carolina*) ranges over the entire eastern USA from southern Canada to northern Mexico.

**Habitat**
Mainly wetter woodland close to watercourses.
In dry southern areas, adapts by restricting activity to rainy months and by hiding in mud or under leaves.
Can tolerate salty water, and all species can tolerate periods of weeks to months away from water.

_Hibernation_
Yes – in northern parts of range.

_Diet_
Young mainly carnivorous (invertebrates, carrion), becoming more herbivorous as they get older.
All eat mushrooms.

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**Cuora spp. (Asian Box Turtles)**

The Amboina box turtle (_C. amboinensis_) is most commonly seen in captivity.

_Distribution_
South-East Asia.

_Habitat_
Swamps, small watercourses and rice paddies.
Can also be found on land.

_Hibernation_
No.

_Diet_
Most are omnivorous – the proportion of meat and vegetation varies from species to species.
Young are more carnivorous than older animals.

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**Trionychidae (Soft-shell Turtles)**

There are a large number of Soft-shelled turtle species – the exact species is often unknown by the owner and the animal’s provenance is not always clear.

Where possible, the animal should be identified and its husbandry based on natural history.

_Distribution_
Asia, southern USA, equatorial Africa, Australasia.

_Habitat_
Typical muddy-bottomed streams, rivers, swamps and lakes.

_Hibernation_
No.

_Diet_
Carnivorous, although some species are omnivorous.
Chelidae (Side-necked/Snake-necked Turtles)

There are a large number of Side-necked turtle species – the exact species is often unknown by the owner and the animal’s provenance is not always clear.

Where possible, the animal should be identified and its husbandry based on natural history; however, all species are tropical/subtropical and have similar habitats, meaning that generalisations may be made in terms of husbandry and diet.

*Distribution*
Asia, southern USA, equatorial Africa, Australasia.

*Habitat*
Generally prefer shallow ponds and slow-moving water.

*Hibernation*
No.

*Diet*
Carnivorous, although some species are omnivorous.

Carettochelys insculpta (Fly River Turtle, or Pig-nosed Turtle)

These are often sold to keep in fish tanks, but this is not recommended as they are piscivorous. However, a typical warm-water tank set-up may be appropriate.

*Distribution*
Southern Papua New Guinea and some rivers of northern Australia.

*Habitat*
Calm rivers and lagoon – may also tolerate salt water and enter the sea.

*Hibernation*
No.

*Diet*
Snails, fish crustaceans and fallen fruit.

*Reproductive data*
- Season: nests July to November, in the dry season.
- Eggs per clutch: 15–30.
- Laying site: shallow nests in mud/sand banks – excavated when females emerge from water at night.
- Incubation time: stimulated to emerge by rising water.

Chelus fimbriatus (Mata Mata)

*Distribution*
Northern South America.
Habitat
Edges of wetlands and slow rivers.

Hibernation
No.

Diet
Carnivorous – especially fish and amphibia.

Reproductive data
- Season: October to December.
- Eggs per clutch: 12–30.
- Laying site: eroding river cliffs.
- Incubation time: 80 days on average, but varies according to humidity and sun exposure.
Determinations of sex is not always straightforward in Chelonia. As described below, the vast majority have temperature/environmental-determined sex rather than genetic-determined sex as in mammals and birds.

This means that DNA cannot be used to determine sex (as is done in avian medicine).

In the clinical setting, imaging may be used to visualise the internal gonads: ultrasonography (Chapter 7.2) can be used to visualise mature follicles on the ovary, although coelioscopy (Chapter 7.3) is most useful in visualising and identifying both mature and immature gonads of either sex. However, this technique will require some form of anaesthesia/sedation and is invasive.

Therefore, it is most useful to be able to physically identify sex from the anatomical characteristics of each species. As well as requiring good knowledge of the species involved (see Chapter 1.1), this also requires a lot of experience in determining often subtle differences. Clinicians interested in improving their knowledge are well advised to spend time with experienced breeders of these species and to examine a lot of individuals. This is especially important when trying to sex juveniles, where the differences between the sexes may be minimal. In these cases, it is important that owners are not misled by a ‘guess’ and uncertainty over the sex of the animal is conveyed to the owner.

Table 1.3.1 gives a brief guide to the different physical characteristics of the sexes in those species covered by this book. Some care is required when using plastron or carapace shape in captive-bred specimens, where abnormal growth and nutritional secondary hyperparathyroidism may affect the shell shape such that the sex-related shape is obliterated.

Environmental sex determination

As discussed above, in most species (the notable exception being the Soft-shelled turtles, Trionychidae), incubation temperature determines sex. It is, of course, vital to know which temperatures produce which sex offspring if a mixed sex population is to be produced and maintained.
<table>
<thead>
<tr>
<th>Species</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Testudo graeca</em></td>
<td>Mediterranean Spur-thighed tortoise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Longer, thicker tail; vent opening beyond the rim of the carapace</td>
<td>• Shorter tail; vent opening at, or cranial to, rim of carapace</td>
</tr>
<tr>
<td></td>
<td>• Concavity of plastron</td>
<td>• Flat plastron; some flattening of caudal carapace dorsal to tail</td>
</tr>
<tr>
<td></td>
<td>• Wider anal scutes</td>
<td>• Narrower anal scutes</td>
</tr>
<tr>
<td><em>T. ibera</em></td>
<td>Greek Spur-thighed tortoise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Longer, thicker tail; vent opening beyond the rim of the carapace</td>
<td>• Shorter tail; vent opening at, or cranial to, rim of carapace</td>
</tr>
<tr>
<td></td>
<td>• Concavity of plastron</td>
<td>• Flat plastron; some flattening of caudal carapace dorsal to tail</td>
</tr>
<tr>
<td></td>
<td>• Wider anal scutes</td>
<td>• Narrower anal scutes</td>
</tr>
<tr>
<td><em>Furculachelys naebulensis</em></td>
<td>Tunisian tortoise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Longer, thicker tail; vent opening beyond the rim of the carapace</td>
<td>Shorter tail, vent opening at, or cranial to, rim of carapace</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Species</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>T. hermanni</em></td>
<td>Long tail, with long keratinised tip</td>
<td>Tail shorter, with shorter keratinised tip</td>
</tr>
<tr>
<td></td>
<td><strong>NB</strong> These differences are very marked in the smaller western subspecies (<em>T. h. hermannii</em>). In the larger eastern subspecies (<em>T. h. boettgeri</em>), the differences are more subtle. As in the Spur-thighed group (see above), there may be differences in the anal scute.</td>
<td></td>
</tr>
<tr>
<td><em>T. horsfieldi</em></td>
<td>Longer tail, with vent close to the tip</td>
<td>Shorter tail; vent more cranial</td>
</tr>
<tr>
<td><em>T. marginata</em></td>
<td>Longer tail, with vent close to the tip</td>
<td>Shorter tail; vent more cranial</td>
</tr>
<tr>
<td><em>T. kleinmanni</em></td>
<td>Longer tail, with vent close to the tip</td>
<td>Shorter tail; vent more cranial</td>
</tr>
<tr>
<td><em>Geochelone sulcata</em></td>
<td>● Anal scute curvature wide and shallow</td>
<td>● Anal scute curvature deeper and narrower</td>
</tr>
<tr>
<td></td>
<td>● Plastron flat</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 1.3.3* Western subspecies – male

*Figure 1.3.5* Note the pointed tail and the shape of the anal scute