Chapter 11
Amphibians and Reptiles

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Abstract The three Mexican states of the Yucatán Peninsula have been relatively well explored for herpetofauna, when compared with other states of the country. However, most studies on the herpetofauna of the Yucatán Peninsula have focused on their diversity, taxonomy, and species distribution, and less on their ecology, behavior or conservation status. The major conservation efforts have focused on sea turtles. Although some conservation programs exist locally for crocodiles in the north of the peninsula, to date conservation strategies have mostly been restricted to the designation of protected areas. With 24 species of amphibians and 118 species of reptiles, the Yucatán Peninsula harbors 11.5 % of national herpetofauna diversity, and 19 % of species are endemic to the peninsula. Reptiles and amphibians are two major globally threatened groups of vertebrates, with amphibians being the most threatened vertebrate class. Both groups face the same threats, namely habitat loss and modification, pollution, overharvest for food and pet trade, introduction of exotic species, infectious diseases, and climatic change. Unfortunately, almost none of these issues have been investigated for key populations in the Yucatán Peninsula. For amphibians, studies exploring the presence of the chytrid fungus (*Batrachochytrium dendrobatidis*) and the effects of climatic change are badly needed to understand the specific factors that negatively affect populations in this area. In general, conservation efforts for reptiles and amphibians in the Yucatán Peninsula need to include environmental education, scientific investigation, and law enforcement and application.

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11.1 Introduction

The herpetofauna of Mexico, with 376 species of amphibians and 864 species of reptiles, corresponds to the fifth and second worldwide positions of diversity of these groups, respectively (Flores-Villela and García-Vázquez 2014; Parra-Olea et al. 2014). The earliest European explorations of the herpetofauna of Mexico go back to the sixteenth century, and although they continued during the following centuries, they were mainly made in southern (e.g., Veracruz, Oaxaca), central (e.g., Mexico City, Puebla), western (e.g., Guanajuato) and northern (e.g., Coahuila) states of Mexico. Published scholarship continues to be conducted mainly by Europeans (Flores-Villela et al. 2004). At the end of the nineteenth century, the states of the Yucatán Peninsula were herpetologically almost unknown, perhaps due to a less attractive diversity of species in comparison with other southern states such as Veracruz, Chiapas, or Oaxaca (Flores-Villela and García-Vázquez 2014; Parra-Olea et al. 2014), or to more difficult access. Nevertheless, at the beginning of the twentieth century the majority of the species of amphibians and reptiles occurring in the Yucatán Peninsula had already been described based on specimens collected in other regions from Mexico, Guatemala, and Belize (Lee 1996). In fact, the first explorations and descriptions of species from specimens of the Yucatán Peninsula started in the late nineteenth and early twentieth centuries and increased between 1920 and 1930, mainly due to an increase in archeological explorations in the state of Yucatán (Lee 1996). In the first half of the twentieth century, Yucatán was thus herpetologically the best-known state of the peninsula, whereas records and collections from Campeche and Quintana Roo remained scarce until the mid-twentieth century, when the first studies of herpetofauna began there (Lee 1996; Flores-Villela et al. 2004). Although Campeche, Yucatán and Quintana Roo are now better known in terms of diversity of amphibians and reptiles species, research on herpetofauna in the Yucatán Peninsula is still limited compared to other states (Flores-Villela et al. 2004). In this chapter, the term Yucatán Peninsula refers to the three Mexican states of Quintana Roo, Campeche and Yucatán (i.e., the geopolitical definition) when speaking of species diversity. When speaking of endemism we refer to the species native to this peninsula, but not necessarily restricted to the Mexican portion of the peninsula, since several of these species extend their range into Belize and/or Guatemala (i.e., the geological definition of the peninsula).

The herpetofauna of the Yucatán Peninsula is composed of 142 species (118 reptiles and 24 amphibians) representing 94 genera and 33 families (Table 11.1), corresponding to 11.5 % of the national species count (1240 species; Parra-Olea et al. 2014; Flores-Villela and García-Vázquez 2014). The state of Quintana Roo shows the highest diversity (130 species: 107 reptiles and 23 amphibians) followed by Campeche (121 species: 100 reptiles and 21 amphibians), and Yucatán

Table 11.1 Taxonomic composition of the herpetofauna of the Yucatán Peninsula and number (%) of endemic and introduced species

Groups	Orders	Families	Genera	Species	Endemic species	Introduced
Reptiles	Crocodilia	1	1	2	0 (0)	0 (0)
	Testudines	6	14	16	2 (12.6)	0 (0)
	Squamata					
	Sauria	10	21	44	9 (20.5)	3 (6.8)
	Serpentes	6	40	56	13 (23.2)	1 (1.8)
	Total	23	76	118	24 (20.3)	4 (3.4)
Amphibians	Caudata	1	1	3	1 (33.3)	0 (0)
	Anura	9	17	21	2 (9.5)	1 (4.8)
	Total	10	18	24	3 (12.5)	1 (4.2)
Total		33	94	142	27 (19.0)	5 (3.5)

(101 species: 84 reptiles and 17 amphibians). Among the 142 species, 24 species of reptiles (20.3 %) and three species of amphibians (12.5 %) are endemic to the peninsula (Table 11.1). These endemics include two turtles, nine lizards, 13 snakes, one salamander and two anurans (Table 11.2). Four species of reptiles and one amphibian species have been introduced: *Hemidactylus frenatus*, *H. turcicus*, *Anolis sagrei,* and *Rhamphotyplops braminus* for reptiles (Lee 1996), and *Eleutherodactylus planirostris* for amphibians (Cedeño-Vázquez et al. 2014).

The peninsula effect (a decrease in species richness from the base to the tip of a peninsula), was originally interpreted as a result of potential colonization/extinction dynamics, attributable to the isolating effects of peninsulas (Ricklefs 1973). Despite the fact that this phenomenon has been documented in Florida for amphibians and reptiles (Keister 1971), and in Florida, Yucatán, and Baja California for birds (Mac-Arthur and Wilson 1967) and mammals (Simpson 1964), according to Lee (1980), in the Yucatán Peninsula this effect is observed among herpetofauna only for anurans (species diversity diminishes dramatically from south to northwest). Rather than an isolation process, this pattern could be explained by climatic effects, as the base is much more moist than the tip of the peninsula. For snakes and lizards, species richness is highest at the base, lowest at the center, and intermediate at the northern end of the region. The number of endemic species is greatest at the northern end and diminishes rapidly to the south (Lee 1980). This can be attributed to the fact that the original vegetation of the northwestern area is dry tropical forest, which is isolated from other such forests, leading to increased endemism. In the following sections, we present a synthesis of information on the diversity and ecology of each group of herpetofauna present in the Yucatán Peninsula. We also describe the various threats that currently face this diversity in the peninsula, and offer prescriptions for the direction of the future research on the herpetofauna in this region.

Table 11.2 Endemic species of amphibians and reptiles to the Yucatán Peninsula

Groups	Order	Species
Amphibians	Caudata	*Bolitoglossa yucatana*
	Anura	*Craugastor yucatanensis*
		Triprion petasatus
Reptiles	Testudines	*Cryptochelys creaseri*
		Terrapene yucatana
	Sauria	*Ctenosaura alfredschmidti*
		Ctenosaura defensor
		Sceloporus chrysostictus
		Sceloporus cozumelae
		Sceloporus lundelli
		Mesoscincus schwartzei
		Aspidoscelis angusticeps
		Aspidoscelis cozumela
		Aspidoscelis rodecki
	Serpentes	*Amerotyphlops microstomus*
		Coniophanes meridanus
		Coniophanes schmidti
		Dipsas brevifacies
		Imantodes tenuissimus
		Sibon sanniolus
		Symphimus mayae
		Tantilla cuniculator
		Tantilla moesta
		Tantillita canula
		Agkistrodon russeolus
		Crotalus tzabcan
		Porthidium yucatanicum

11.2 Amphibians

The amphibian community of the Yucatán Peninsula consists of 24 species, distributed in 18 genera, 10 families, and two orders. The order Caudata is represented by three species of lungless salamanders (Plethodontidae) of the genus *Bolitoglossa*, the northern banana salamander (*B. rufescens*), the Mexican mushroomtongue salamander (*B. mexicana*), and the endemic Yucatán mushroomtongue salamander (*B. yucatana*) (Fig. 11.1a). Like other plethodontid salamanders, they presumably exhibit direct development (there is no free-living aquatic stage involved). The eggs are deposited in moist terrestrial substrates, and the larvae complete their development within the egg and hatch into miniature replicas of the adults. There is no specific information on the reproduction of *B. rufescens* and *B. yucatana*, but clutch size in *B. mexicana* may be up to 63 eggs (Wake and Lynch 1976). Gas exchange is effected through skin and tissues lining the mouth and pharynx (Lee 1996). *Bolitoglossa rufescens* is small (reaching

Fig. 11.1 (**a**) The endemic Yucatán Mushroomtongue Salamander (*Bolitoglossa yucatana*) by G. Köhler. (**b**) The endemic Yucatán Casque-Headed Tree Frog (*Tripion petasatus*) by J.R. Cedeño Vázquez. (**c**) The Black-Backed Frog (*Leptodactylus melanonotus*) by G. Köhler.

a maximum snout-vent length [SVL] of 28–33 mm) compared to the mid-sized *B. yucatana* (49–55 mm SVL) and *B. mexicana* (55–80 mm SVL). They are uncommon, both arboreal and terrestrial, and found beneath surface debris, limestone rocks, logs, and on roads at night. During the dry season they likely inhabit leaf axils of bananas, bromeliads, and other water-retaining epiphytes (Wake and Lynch 1976; Calderón-Mandujano et al. 2003). The terrestrial activity of these salamanders is probably restricted to the rainy season. They feed on a variety of small invertebrates, including ants and termites (JRCV pers. obs.); the examination of droppings of a specimen of *B. yucatana* collected close to Chetumal city revealed that ants were the main source of food (Cedeño-Vázquez et al. 2006a).

In toads and frogs (Anura), fertilization is usually external, although internal fertilization occurs in a few species. Most of the species of the Yucatán Peninsula deposit their eggs in water, which hatch into aquatic larvae that subsequently metamorphose into froglets. Some frogs place their eggs in foam nests (genus *Leptodactylus* and *Engystomops*), while other species deposit eggs on vegetation overhanging water (*Agalychnis callidryas* and *Dendropsophus ebraccatus*). Still others (the endemic Yucatán rainfrog *Craugastor yucatanensis* as well as the introduced greenhouse frog *Eleutherodactylus planirostris*) lay their eggs in moist terrestrial sites, where they undergo direct development. During the breeding season, adult males call from temporary or permanent water bodies to attract females for mating. In general, adult females are larger than males. The anurans in the Yucatán Peninsula possess external vocal sacs, except *Rhinophrynus dorsalis,* which has internal sacs. Most species have unpaired vocal sacs in subgular positions (e.g., *Incilius valliceps*). Paired vocal sacs may be in subgular (e.g., *Smilisca baudinii*) or lateral positions, that is, they lie posterior to the angle of the jaws (e.g., *Trachycephalus typhonius* and *Lithobates brownorum*).

The burrowing toad (*Rhinophrynus dorsalis*), the only living species of the family Rhinophrynidae, is relatively large in size (63–80 mm SVL) and its body is globose, flaccid, and covered with loose skin. This fossorial toad is common and is generally found in savannas and seasonal forests (Duellman 1971). Surface activity of adults is restricted to the beginning of the summer rainy season, when males call from temporary bodies of water, females produce clutches of several thousand eggs (Lee 1996). Adults feed on insects, especially ants and termites (McCoy 1966), and during the dry season pass long periods in subterranean chambers of their own construction (Foster and McDiarmid 1983).

Fig. 11.1 (continued) (**d**) The Tungara Frog (*Engystomops pustulosus*) by J.R. Cedeño Vázquez. (**e**) The American Crocodile (*Crocodylus acutus*), note the well-developed preorbital elevation, by P. Charruau. (**f**) The critically endangered Central American River Turtle (*Dermatemys mawii*) by G.A. González-Desales. (**g**) The Yucatán Banded Gecko (*Coleonyx elegans*) by G. Köhler. (**h**) The Allison's Anole (*Anolis allisoni*) by P. Charruau. (**i**) The endemic Yucatecan Cantil (*Agkistrodon russeolus*) by G.A. González-Desales. (**j**) The Snail-Eating Thirst Snake (*Dipsas brevifacies*) by G. Köhler

Two bufonid toads are present in the peninsula: the Gulf Coast toad (*Incilius valliceps*, formerly known as *Bufo valliceps*) and the marine toad (*Rhinella marina*, formerly known as *Bufo marinus*). Both are stout, have large parotid glands on the neck, and a thick, glandular and wart-covered dry skin. The parotoid glands produce a toxic secretion with pharmacological properties. Dogs have been known to die from biting *R. marina*. *Incilius valliceps* is moderate-sized (73–100 mm SVL) compared to *R. marina*, which is the largest (150–200 mm SVL) anuran in the Yucatán Peninsula. These nocturnal and terrestrial toads are abundant in most habitats within the Yucatán Peninsula, including open habitats (common in disturbed areas and in association with human habitation). In contrast, *R. marina* is uncommon or absent from closed-canopy forests (Lee 1996). Breeding may occur throughout the year in both species, but in *I. valliceps* individuals are cued by the first heavy rains at the onset of the summer rainy season. Females of both species release eggs in long strings into water, where they hatch and where tadpoles complete their development. While *I. valliceps* feeds predominantly on insects, *R. marina* consumes a wide variety of invertebrate and vertebrate prey, including smaller members of their own species (Easteal 1986). Despite their presumably noxious skin secretions, *I. valliceps* members are common items in the diet of snakes like *Drymobius margaritiferus*, *Xenodon rabdocephalus*, and *Drymarchon melanurus* (Lee 1996; Cedeño-Vázquez et al. 2006a; JRCV pers. obs.).

The arboreal hylid frogs are the most diverse family in the region, with nine species from seven genera. They are nocturnal and feed on a variety of invertebrates, especially insects and spiders. Larger-sized species (e.g., *Trachycephalus typhonius* [formerly known as *Phrynohyas venulosa*] and *Triprion petasatus*) may also eat small vertebrates such as other frogs. Based on their size we can distinguish two groups of hylid frogs in the region. The first group is composed of four small (18–30 mm SVL) and slender species (*Dendropsophus microcephalus* [formerly known as *Hyla microcephala*], *D. ebraccatus* [formerly *Hyla ebraccata*], *Scinax staufferi*, and *Tlalocohyla picta* [formerly *Hyla picta*]). The second group is integrated by five mid-sized to large (38–102 mm SVL) species (*Agalychnis callidryas*, *Smilisca baudinii*, *Tlalocohyla loquax* [formerly known as *Hyla loquax*], *Trachycepahlus typhonius*, and *Triprion petasatus*). Most species are relatively common in forests and open areas (i.e., savannas, pastures), but some (e.g., *S. baudinii* and *T. typhonius*) are frequently more widespread, including urban zones, especially during the rainy season (Lee 1996). During daylight hours and during the dry season, some species (e.g., *S. staufferi*, *S. baudinii*, and *T. typhonius*) hide beneath the bark on standing trees, within tree holes and crevices, or in arboreal vegetation such as bromeliads and other water-retaining plants. The endemic Yucatán casque-headed treefrog (*T. petasatus*) (Fig. 11.1b) is particularly abundant in the arid northwestern portion of the peninsula. During the day these frogs seek refuge in the recesses of tree trunks and in rock crevices, where they plug the openings with their bony head, making them nearly impossible to extract (Lee 1996). This behavior probably helps to prevent desiccation and predation.

Hylid frogs are common prey of a variety of colubrid snakes like *Leptophis mexicanus*, *L. ahaetulla*, and *Coniophanes imperialis* (Cedeño-Vázquez et al. 2006a; JRCV pers. obs.). Breeding activity is associated with summer rains, when anywhere from few to hundreds of males congregate at water bodies and call from trees, shrubs, and emergent grasses. Small clutch sizes are typical for the two species that deposit egg masses on vegetation overhanging the water: *D. ebraccatus* generally deposits clutches of 20–80 eggs, while *A. callidryas* produces multiple clutches of 20–50 eggs per breeding episode (Lee 1996). The other hylid species produce masses of hundreds of eggs in the water, where the tadpoles complete their development (Lee 1996).

Two frogs have direct development, the endemic Yucatán rainfrog (*Craugastor yucatanensis* [formerly known as *Eleutherodactylus yucatanensis*], family Craugastoridae) and the invasive greenhouse frog (*Eleutherodactylus planirostris,* family Eleutherodactylidae). The biology of *C. yucatanensis* is poorly understood. The type specimen was collected in a cave, suggesting that these small (30–34 mm SVL) frogs are terrestrial and inhabit sinkholes (*cenotes*) and caverns (Lee 1996), but Calderón-Mandujano et al. (2008) state that these frogs are arboreal. These authors observed adult males calling (the call is like the cheep of a young chicken) in the forests of Sian Ka'an Biosphere Reserve, where the species is abundant and more active at night, especially after rainfall episodes. The tiny (16–32 mm SVL) greenhouse frog is native to the Caribbean islands of Cuba, Bahamas, and Cayman Islands (Díaz and Cádiz 2008; Olson et al. 2012), but has been introduced in several countries of the Neotropics. It was recently recorded in the Mexican Caribbean (Cedeño-Vázquez et al. 2014). Direct development facilitates human-mediated colonization of this frog (Christy et al. 2007) through transportation in potted plants (Kraus et al. 1999; Kraus and Campbell 2002). It feeds mostly on leaf litter invertebrates; in Hawaii, Olson and Beard (2012) estimated a mean consumption of 129,000 invertebrates/ha/night by these little frogs. Research to assess the invasion and its possible ecological impacts in the Mexican Caribbean is required to determine if control is necessary (Cedeño-Vázquez et al. 2014).

Three species of the genus *Leptodactylus* (family Leptodactylidae) occur in the peninsula. These are nocturnal, semiaquatic or terrestrial, small to mid-sized frogs (30–50 mm SVL) that construct foam nests within which they deposit their eggs; these nests provide protection against desiccation and predation. They breed during the rainy season in permanent ponds (*aguadas*) and temporary bodies of water, including roadside ditches, flooded pastures, small puddles, and even hoof prints of horses and cattle, often in close association with human settlements (Lee 1996). The white-lipped frog (*Leptodactylus fragilis*) and the black-backed frog (*L. melanonotus*) (Fig. 11.1c) are widespread and common species that occur in a variety of habitats across the peninsula. Whereas foam nests of *L. fragilis* are usually placed in sites subject to flooding to ensure the release of the larvae from the nest, *L. melanonotus* constructs foam nests at the water's edge. Tungara frogs (*Engystomops pustulosus* [formerly known as *Physalaemus pustulosus*], family Leiuperidae) (Fig. 11.1d) live in open areas (savannas) and deciduous forests of southern Campeche and Quintana Roo. They are rarely found, except at breeding congregations. Multiple clutches (200–300 eggs per clutch) are deposited in foam nests in shallow water (Rand 1983). Tadpoles hatch after 6 days and complete metamorphosis within 4–6 weeks (Galindo-Leal 2003). Their calls attract predators, such as the bat *Trachops cirrhosus,* and it is reported that tadpoles of *A. callidryas* feed on tadpoles of *E. pustulosus* when their nests have been broken apart by heavy rain (Ryan 1985).

Two small-sized (24–38 mm SVL) species of narrow-mouthed frogs (family Microhylidae) occur in the peninsula, the elegant narrow-mouthed toad (*Gastrophryne elegans*) and the sheep toad (*Hypopachus variolosus*). They are characterized by their chubby shape, short limbs, pointed heads, and a fold of skin across the back of the head. During the rainy season males call from temporary bodies of water, usually from the surface, and eggs are deposited directly into the water. The uncommon and inconspicuous *G. elegans* lives in leaf litter and crevices in moist soil (Cedeño-Vázquez et al. 2006a) in humid lowland forests, although individuals are occasionally found on the forest floor at night. As with most species of *Gastrophryne,* it feeds on small insects, particularly ants, termites, and small beetles (Nelson 1972; Köhler 2011). *Hypopachus variolosus*, in contrast, is widespread and common in both forested and more open areas (Lee 1996). Terrestrial and fossorial, it feeds on small arthropods, particularly insects such as ants and termites (Cedeño-Vázquez et al. 2006a; Köhler 2011). *Hypopachus variolosus* is often found at night on roads after heavy rains (Lee 1996). Typical of an explosive breeder, these frogs emerge after heavy downpours, mostly during the early rainy season, and use temporary waters bodies such as flooded pastures, roadside ditches, and marshes for reproduction (Lee 1996; Savage 2002). In addition, they occasionally breed in tree hollows above ground (McDiarmid and Foster 1975).

Finally, there are two mid-sized (60–114 mm SVL) species of true frogs (family Ranidae) of the genus *Lithobates*. These are classic frogs with smooth skin, long legs, and semi-aquatic habits, and are excellent jumpers (Galindo-Leal 2003). They feed primarily on invertebrates, but also on small vertebrates like fish, frogs, and mid-sized lizards (Lee 1996; Terán-Juárez 2011). They breed during the summer rainy season; the tadpoles develop in ponds where the eggs are laid. *Lithobates brownorum* (formerly known as *Rana berlandieri*) is terrestrial, diurnal and nocturnal. It is widely distributed throughout the Yucatán Peninsula (Zaldívar-Riverón et al. 2004), and is commonly found in and around freshwater bodies, reaching high densities in open, disturbed settings. During the reproduction period, males call from the surface of permanent or temporary bodies of water. The Vaillant's frog *L. vaillanti* (formerly known as *Rana vaillanti*) is terrestrial and lives primarily in humid lowland forests throughout the base of the peninsula, generally in lakes, *aguadas*, woodland pools, and slow-moving stretches of streams and rivers, but individuals have also been found at night on the forest floor (Lee 1996). Males call from the water's edge or surface during the breeding season.

11.3 Crocodiles

Two species of crocodiles occur in the Yucatán Peninsula, the American crocodile *Crocodylus acutus* and the Morelet's crocodile *C. moreletii*. Both species were intensively hunted for their skin during the last century, and their populations have decreased drastically. Today, populations of *C. moreletii* seem to have recovered, but continental populations of *C. acutus* remain in low numbers and exhibit poor recruitment (Cedeño-Vázquez et al. 2006b). However, island populations of *C. acutus* appear relatively well preserved but exhibit a male-biased sex ratio (Charruau et al. 2005; González-Cortés 2007).

Crocodylus moreletii inhabits inland freshwater systems on the mainland, while *C. acutus* occur in coastal saltwater habitats including offshore atolls and islands (Cedeño-Vázquez et al. 2006b; Charruau et al. 2005; González-Cortés 2007). Both species occur sympatrically in several areas of brackish mangrove swamp on the mainland (Cedeño-Vázquez et al. 2006b), where hybridization occurs (Cedeño-Vázquez et al. 2008; Rodriguez et al. 2008; Machkour M'rabet et al. 2009). Continental populations of *C. acutus* show high levels of hybridization and introgression with *C. moreletii*, while island populations remain apparently genetically pure (Machkour M'rabet et al. 2009). Hybridization may also complicate the identification of individuals in sympatric areas, as hybrids are cryptic or present characteristics of both species (Cedeño-Vázquez et al. 2008).

Crocodylus acutus and *C. moreletii* differ only by subtle morphological characteristics, such that the correct identification of the species can pose problems even to experienced herpetologists (Platt and Rainwater 2006). Differences in scale arrangements and skull morphology are the principal useful characteristics for identification of the species. *Crocodylus moreletii* is a mid-sized crocodile with males presumably reaching a maximum total length of 4.5 m (Platt et al. 2009), although individuals of more than 3.5 m are rare in the peninsula. This species presents a broad snout, weakly keeled osteoderms on the back, and irregular scales on the ventral and lateral surfaces of the tail (Platt and Rainwater 2006). In contrast, *C. acutus* is a large species, with males reaching maximum total lengths of more than 6 m and females generally reaching maximum total lengths of 3.5 m with exceptional individuals of 4.4 m reported (Thorbjarnarson 2010). However, individuals of more than 4 m are now rare in the peninsula. This species has a longer and more slender snout than *C. moreletii* and shows a well-developed preorbital elevation (Fig. 11.1e) (Platt and Rainwater 2006). *Crocodylus acutus* has also the most reduced and irregular pattern of dorsal osteoderms of any crocodilian (Platt and Rainwater 2006). Moreover, *C. acutus* generally presents many fewer caudal irregular scales than *C. moreletii* and usually never shows irregular scales on ventral surface of the tail (Platt and Rainwater 2006).

Crocodiles are opportunistic predators that eat a large array of prey. Studies in the Yucatán Peninsula show that the diet of *Crocodylus acutus* and *C. moreletii* includes insects, arachnids, mollusks, crustaceans, fish, amphibians, reptiles, birds and mammals (Gómez-Hernández 2004; Platt et al. 2002, 2006, 2007, 2013a). Moreover, frugivory, necrophagy, and kleptoparasitism have been observed, as well as the presence of stones in the stomach of some individuals (i.e., gastroliths; Platt et al. 2002, 2006, 2007, 2013b). In both species, the diet varies as a function of ontogenic development (Platt et al. 2006, 2013a). Hatchlings and small juveniles are the most specialized classes, feeding mainly on insects and arachnids; larger juveniles and subadults have the most diverse diet, increasing their consumption of fish and non-fish vertebrates. The diet of adults differs between species: *C. acutus* feeds principally on crustaceans, whereas *C. moreletii* has a broader diet including gastropods, crustaceans, fish, mammals, birds and reptiles (Platt et al. 2006, 2013a). Dietary overlap is greatest between adjacent size classes and least between the smallest and largest size classes (Platt et al. 2006, 2013a).

All crocodilians are oviparous and lay a single clutch of hard-shelled eggs per year. However, *Crocodylus acutus* and *C. moreletii* show clear differences in their reproductive ecology. *Crocodylus moreletii* is a mound nester: the female builds a mound nest of fresh and decomposing vegetation, sticks and mud, or soil, into which 20–50 eggs are deposited at the end of the dry season (Platt et al. 2008). The incubation period lasts 75–85 days; hatching occurs in August and September during the peak of the wet season (Platt et al. 2008). Females are very protective and remain in the vicinity of the nest during incubation, attacking potential egg predators. At hatching, the female excavates the nest, helps the hatchlings to emerge, and transports them to the water's edge, where she protects them from predators (Platt et al. 2010). *Crocodylus acutus*, on the other hand, is a hole nesting species. The female excavates a hole in open sandy areas into which 9–60 eggs are laid, and then re-covers them with substrate, sometime creating slightly elevated mounds (Charruau et al. 2010a; Thorbjarnarson 2010). Nesting occurs generally during the dry season and hatching during the beginning of the rainy season (Charruau et al. 2010a; Thorbjarnarson 2010). Maternal behavior of this species seems variable but on Banco Chinchorro atoll, females have been observed to visit their nests, rebuild them when disturbed, help hatchlings to emerge from the nest, and transport them to the water (Charruau and Hénaut 2012).

Crocodylus acutus and *C. moreletii*, like all crocodilians, have temperature-dependent sex determination (TSD), in which sex of embryos is determined during incubation by the action of temperature on the sexual differentiation system during a thermo-sensitive period (Charruau 2012; Lang and Andrews 1994). Both species show a FMF (Female-Male-Female) TSD pattern where low and high incubation temperatures produce a majority of females (up to 100 %) and intermediate temperatures produce a majority of males (Charruau 2012; Lang and Andrews 1994).

11.4 Turtles

The turtle fauna of the Yucatán Peninsula consists of 16 species in 14 genera and six families. This count includes five marine and 11 continental forms. The later includes freshwater (five species), semi-aquatic (four species), semi-terrestrial (one species), and terrestrial (one species) turtles.

As with crocodilians and other reptiles, temperature-dependent sex determination (TSD) is common in turtles, but no data exist on this for the species of the peninsula. Sea turtles (families Dermochelydae and Cheloniidae) are strictly marine, but normally come ashore to lay eggs in sandy beaches. As adaptations to aquatic life, they have forelimbs that have evolved into paddle-shaped fins, and salt glands, which expel superfluous salt that has been ingested through feeding (Köhler 2008). Adult sea turtles are among the largest living reptiles and the only reptiles that exhibit long-distance migrations, comparable only with those of terrestrial and avian vertebrates (Plotkin 2003).

Five species of sea turtles, all endangered, inhabit the waters surrounding the Yucatán Peninsula. These are the leatherback (*Dermochelys coriacea*), which is the only species of the family Dermochelydae, and four species of hard-shelled sea turtles (family Cheloniidae): the loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*).

The leatherback is the largest of all living turtles. The largest specimen ever measured had a carapace (shell) length of 256.5 cm and a mass of 916 kg (Márquez 1990). They usually stay in the open ocean and are observed only occasionally near the coast (Köhler 2008). They are mostly carnivorous and feed on a variety of invertebrates, mainly tunicates and jellyfish (and the fish and crustaceans associated with jellyfish), though they do occasionally consume seaweeds (Mortimer 1982). Females undertake reproductive migrations to nesting beaches every 2–3 years, where they emerge from the sea at night to oviposit five or six clutches at 9-day intervals (Boulon et al. 1996; Steyermark et al. 1996). Females do not display strong beach fidelity and may travel among adjacent (Steyermark et al. 1996) or distant beaches (Keinath and Musick 1993) over the course of a nesting season. The nesting season in the Yucatán Peninsula lasts from April to October (Köhler 2008). Leatherbacks are thought to nest on Arrecife Alacrán, Yucatán (Carranza 1959), and are known to nest at several coastal locales in Campeche and Quintana Roo (Lee 1996).

The loggerhead (*Caretta caretta*) is the largest species of the family Cheloniidae (Lee 1996); the adults attain a carapace length of up to 230 cm and a mass of 540 kg (Pritchard 1967). Loggerheads are abundant and spend most of their time in nearshore and inshore shallow waters, sometimes associated with reefs and other natural and artificial hard substrates (Dodd 1988). They feed on a variety of invertebrates including, but not limited to: crabs, barnacles, gastropods, bivalve mollusks, shrimps, squids, and jellyfish, as well as fish (Lee 1996). The eggs are especially vulnerable to predation by a variety of terrestrial animals, including insects (e.g., larvae of the beetle *Lanelater sallei*) and mammals such as the raccoon *Procyon lotor* (Talbert et al. 1980; Donlan et al. 2004), while hatchlings suffer high mortality from numerous invertebrate and vertebrate predators Dodd (1988). They nest in large numbers on the coast of Quintana Roo, from Punta Allen to Isla Contoy, and along the Yucatán and Campeche beaches to Isla del Carmen, Campeche (Lee 1996). The females crawl up onto the nesting beaches at night, laying eggs from April to July (Lee 1996; Köhler 2008). After a short mating phase that occurs offshore, females produce 2–5 clutches, each of 40–190 eggs at intervals of about 2 weeks (Köhler 2008). Young hatch after 55–68 days of incubation (Magnuson et al. 1990; Márquez 1990).

The green turtle (*Chelonia mydas*) is a mid-sized sea turtle: the carapace can measure up to 150 cm in length (Lee 1996; Köhler 2008). This turtle inhabits relatively shallow coastal waters with abundant marine grasses (Lee 1996). Seaweeds and sea grass are the major components of its diet, but it also feeds upon sponges, mollusks, jellyfish, and fish (Mortimer 1982; Lee 1996; Köhler 2008). The waters off the northwest and southeast coasts of the Yucatán Peninsula are important feeding areas for this species (Carr 1952). During the nesting season (April to October), solitary females come to land at night and produce two to five clutches at intervals of 12–14 days, each with 38–150 eggs, from which the young hatch after 50–75 days (Magnuson et al. 1990; Márquez 1990; Lee 1996). Females nest every 2–5 years (Köhler 2008). Along the peninsula, females nest on Islas Contoy, Isla Mujeres and Cozumel Island, Quintana Roo (Smith and Smith 1979), and on Cayo Arcos, Isla Arena, Arrecife Alacrán, and Arrecife Triángulos on the Campeche Bank (Hildebrand 1982).

The hawksbill (*Eretmochelys imbricata*) is a rather small sea turtle, with a maximum carapace length of 100 cm, although most specimens today are considerably smaller. Hawksbills exhibit a pronounced sexual dimorphism, with females growing larger than males (Lee 1996). It inhabits shallow coastal waters, especially rocky substrates and coral reefs, but also occurs in regions with muddy bottoms, and sometimes enters the lower reaches of streams (Lee 1996). This turtle is mostly carnivorous, feeding especially on encrusting organisms such as sponges, sea anemones, bryozoans, tunicates, mollusks, and algae, which it scrapes off reef faces (Mortimer 1982). It also consumes crabs, jellyfish, squid, and fish (Lee 1996; Köhler 2008). There is an argument for the appearance of geographical differences in regard its range of foods, since in some regions individuals feed primarily or exclusively upon sponges (Carr and Stancyk 1975; Meylan 1988). In the Yucatán Peninsula it can be found at any coastal locality; its nesting distribution includes the beaches of southwestern Campeche and northeastern Yucatán (Carranza 1959; Fuentes 1967), but it is particularly abundant along the Caribbean coast (Hildebrand 1982; Meylan 1989). Nesting specimens have been reported elsewhere only sporadically (Köhler 2008). Females breed every 2–3 years, and nest at night, usually at high tide (Lee 1996) once or twice during the breeding season (April to August) to bury clutches consisting of 50–223 eggs each (Lee 1996; Köhler 2008). The incubation period lasts 47–75 days (Márquez 1990). Hatchlings and juveniles are apparently pelagic, but at a carapace length of about 23–25 cm they become benthic feeders in coastal habitats (Meylan 1988).

Kemp's ridley (*Lepidochelys kempii*) is the smallest sea turtle. The carapace length of adults averages 60–65 cm, and there is little or no sexual dimorphism (Lee 1996). This sea turtle is found throughout the Gulf of Mexico with confirmed records from Campeche and Yucatán, but apparently not on the Caribbean coast of the Yucatán Peninsula (Lee 1996). It prefers relatively shallow waters and the crustacean-rich banks of the Campeche—Tabasco area, which represent an important feeding ground (Hildebrand 1982; Byles 1989). This turtle is primarily carnivorous, feeding mostly on crabs, especially those of the genera *Ovalipes* and *Callinectes* (Mortimer 1982), but occasionally they may eat other invertebrates (e.g., sponges, sea anemones, jellyfish, and squids) and plant material (Lee 1996; Köhler 2008). In contrast with the other sea turtles described, the females of *L. kempii* usually lay eggs on beaches during the day (Lee 1996; Köhler 2008). Nesting is generally synchronized, and large numbers of females emerge from the ocean at the same time, producing huge aggregations (Lee 1996; Köhler 2008). These groups once numbered many thousands of individuals (Magnuson et al. 1990), but now are reduced to a few hundred (Lee 1996). Also remarkable is the fact that females nest almost every year, producing 2–3 clutches from April to August, each with 42–167 eggs; the incubation period is about 50–66 days (Casas-Andreu 1978).

The 11 species of continental turtles belong to three families, the most diverse being Kinosternidae, with six species in four genera, followed by Emydidae with three species in three genera, and Dermatemydidae and Chelydridae with one species each. The family Kinostenidae contains two musk turtles (*Claudius angustatus* and *Staurotypus triporcatus*) and four mud turtles (genus *Kinosternon* and *Cryptochelys*), including one that is endemic (*Cryptochelys creaseri*). Kinosternid turtles inhabit slow-moving bodies of water such as lakes, swamps, seasonally flooded marshes, temporary ponds, roadside ditches, *aguadas*, *cenotes*, lagoons in large rivers, and small streams, especially those with muddy bottoms in open or forested areas (Lee 1996; Legler and Vogt 2013). Frequently, kinosternids (*Claudius* and *Kinosternon*) can be encountered on land as they wander from one body of water to another (Köhler 2008; Legler and Vogt 2013). During the dry season, they bury themselves in the loose soil or mud at the site of temporary bodies of water and remain in aestivation until the beginning of the rainy season (Lee 1996; Legler and Vogt 2013).

The monotypic narrow-bridged musk turtle (*Claudius angustatus*) is characterized by a small plastron, which is connected to the carapace by ligaments (Lee 1996; Köhler 2008). It attains a maximum carapace length of about 17 cm, and males generally are 10 mm bigger than females (Lee 1996). This turtle is carnivorous and preys on invertebrates (e.g., snails, earthworms, crustaceans, insects and arachnids) and small vertebrates (Lee 1996; Köhler 2008; Legler and Vogt 2013). It reproduces after the annual floods, and oviposition occurs in November (Pritchard 1979). Clutch size varies from 1 to 8 eggs, which hatch after an incubation period of

94–150 days depending on the environmental conditions (Ernst and Barbour 1989; Vogt and Flores-Villela 1992; Köhler 1997).

The Mexican musk turtle (*Staurotypus triporcatus*) is the largest kinosternid in the Yucatán Peninsula; the adults may attain a maximum carapace length of 40 cm and weight 10 kg (Lee 1996; Legler and Vogt 2013). When disturbed they can be extremely aggressive, so they need to be handled with great caution, because their strong sharp jaws can cause serious wounds (Lee 1996; Köhler 2008). The strongly developed dorsal keels help to stabilize the carapace, thereby making it more difficult for predators (e.g., *Crocodylus moreletii*) to break (Köhler 2008). This turtle is strictly aquatic, and it is most abundant in rivers with slow current at depths of 1–2 m, generally along shorelines where they forage (Legler and Vogt 2013). They are carnivorous, feeding on crabs, worms, snails, bivalves, insects, amphibians, fish, aquatic birds and reptiles such as snakes and mud turtles (Pritchard 1979; Campbell 1998; Köhler 2008; Legler and Vogt 2013). During the reproductive season, the female buries several clutches, each with three to ten eggs (Köhler 2008). Incubation lasts 120–207 days (Ernst and Barbour 1989; Köhler 1997).

The mud turtles were recently divided in two genera: *Kinosternon* and *Cryptochelys* (Iverson et al. 2013). Their members are characterized by having one or two moveable hinges in the plastron that enable complete closure of the shell (Lee 1996; Köhler 2008). The four species that occur in the Yucatán Peninsula are small to mid-sized: *Cryptochelys acuta* are the smallest (9–12 cm of carapace length) and *Kinosternon scorpiodes* the largest (15.7–17.5 cm of carapace length). In *C. acuta*, females are larger than males, while in the remaining species (*Cryptochelys creaseri*, *Cryptochelys leucostoma* and *K. scorpiodes*) males are larger than females (Lee 1996). The most common species locally is *K. scorpiodes*, which can be found in abundance (Lee 1996), followed by the endemic *C. creaseri*, which is most abundant in eastern Yucatán and northern Quintana Roo (Iverson 1988). The diet of *C. acuta* in the Yucatán Peninsula is poorly known, but like other species of the genus it probably feeds primarily on aquatic invertebrates, such as snails, worms, and insects (Köhler 2008). *C. leucostoma* and *K. scorpiodes* consume large quantities of plant material (e.g., leaves, stems, seeds, fruits, and flowers), but are facultative omnivores, also preying prey on small vertebrates (e.g. fish, frogs, lizards, and snakes), including carrion (Iverson 1976, 1988; Vogt and Guzman-Guzman 1988; Köhler 2008), when these are available. The reproduction of these kinosternids is poorly known in the Yucatán Peninsula, but in other places nesting occurs from March to April, and females produce multiple clutches, which, depending on the species, contain from one to ten eggs (Köhler 1997).

The family Emydidae is represented in the Yucatán Peninsula by two mid-sized (15–20 cm of carapace length) species of predominantly terrestrial turtles, *Rhinoclemmys areolata* and the endemic *Terrapene yucatana*, and a large-sized (24–60 cm carapace length), predominantly aquatic slider turtle (*Trachemys venusta*). Although in the Yucatán Peninsula the furrowed wood turtle (*R. areolata*) typically inhabits savannas and other open areas, it also occurs in forests and marshy grounds (Lee 1996). It is frequently found during the day, especially during the summer rainy season (Lee 1996). Little is known about its diet in the Yucatán Peninsula itself, but based on analysis of feces of two specimens from northern Belize examined by Platt (1993), it feeds on plant material (e.g., herbs, legumes, and fruits), beetles and other insects, and turtle eggs. In a recent study, Vogt and co-author (2009) showed that the plants consumed by *R. areolata* in Belize vary seasonally. Data collected in Cozumel, Quintana Roo indicate that sexual maturity in this turtle occurs at about 14.5–15 cm of carapace length and at ages of 9–10 years (Legler and Vogt 2013). Nesting occurs from May to July, and females may lay up to 4–5 clutches per year, each with one large egg, which hatches in 80–90 days (Vogt et al. 2009; Legler and Vogt 2013). The Yucatán box turtle (*T. yucatana*) has been considered a subspecies (*T. carolina yucatana*), but following Legler and Vogt (2013), we treat this taxon as a full species. It inhabits wet savannas and pastureland, as well as thorn forest and evergreen rain forest, with preference for open habitats (Lee 1996). Although it exhibits a terrestrial lifestyle, individuals may occasionally enter shallow water (Lee 1996; Köhler 2008). No reports of the diet of this turtle are available, but according to available data from other species of *Terrapene*, omnivory can be assumed (Legler and Vogt 2013). Information on the reproduction of the Yucatán box turtle is also absent. However the dissection of three females by Legler (see Legler and Vogt 2013) in Yucatán suggests that clutches are small (2–3 eggs), with the first clutch is laid in July; that follicular potential for a second clutch exists, and that mature females may skip seasons of reproduction. The common slider (*T. venusta*) has often been placed in the genera *Pseudemys* and *Chrysemys*, and much of the literature referring to this turtle is found under those names (Lee 1996). Formerly, *T. venusta* was treated as a subspecies of *T. scripta* (*T. scripta venusta*), but we follow Seidel (2002) who elevated this subspecies to full specific status. This large turtle is diurnal and commonly occupies freshwater habitats, with a preference for quiet waters with soft bottoms, such as ponds, rivers, streams, lakes, *aguadas* and *cenotes* (Lee 1996; Köhler 2008). Occasionally individuals do wander some distance from water, particularly during the rainy season (Lee 1996). *Trachemys venusata* usually basks on partially submerged rocks, roots, and logs (Köhler 2008). They feed predominantly on aquatic vegetation (leaves, stems), aquatic invertebrates (mollusks, insects), and fish (Lee 1996). This species is commonly preyed upon by humans and crocodiles (Lee 1996; Köhler 2008). Himmelstein (1980) described a specimen from Quintana Roo that had punctures on the carapace and plastron, suggesting attempted predation by a crocodile. During the egg laying period (December–May) females will construct a flask-shaped cavity about 15 cm deep into which they place 9–25 eggs; a female may produce up to six clutches per season, and juveniles (carapace length 30–33 mm) hatch after an incubation period of 65–85 days (Lee 1996; Köhler 2008). Females are sexually mature at an age of 5–7 years and a carapace length of 20–24 cm (Lee 1996).

The family Dermatemydidae comprises a single living genus and species, the Central American river turtle (*Dermatemys mawii*) (Fig. 11.1f). This very large aquatic turtle may reach a carapace length of 65 cm and a mass up to 22 kg (Lee 1996). This turtle commonly inhabits large deep rivers, and associated oxbow freshwater lakes and lagoons throughout the year (Legler and Vogt 2013), though occasionally it enters brackish water (Lee 1996; Viveros-León 1996; Calderón-Mandujano 2008; Köhler 2008). These nocturnal turtles are able to perform prolonged dives (Köhler 2008). *Dermatemys* is completely herbivorous from hatching to adulthood (Vogt and Flores-Villela 1992), feeding almost exclusively on plant material such as algae, aquatic grasses, leaves, flowers and fruits that fall into the water (Holman 1963; Álvarez del Toro et al. 1979; Lee 1996; Köhler 2008; Legler and Vogt 2013). During the rainy season they enter flooded forest, and also travel up smaller tributaries to nest (Legler and Vogt 2013). The egg-laying period lasts from April through September (Smith and Smith 1979), and females bury their clutches of 2–20 eggs on sandy banks near the shoreline (Polisar 1992; Köhler 2008). Females produce up to three clutches per year (Lee 1996). In Belize the incubation period lasts 217–300 days from oviposition to hatching, and a maximum of four clutches and 47 eggs per year was observed (Polisar 1992). There are many animals (e.g. coati, otter, herons and other large wetland birds, and crocodiles) that prey on this turtle during all its life stages (see references in Legler and Vogt 2013), but humans are clearly the major predator of *Dermatemys*, and hunter-gatherers have probably exploited this food source for centuries (Legler and Vogt 2013).

The Central American snapping turtle (*Cheydra rossignoni*) was previously recognized by Gibbons et al. (1988) as a subspecies of *C. serpentina* (*C. s. rossignoni*). Here we follow Legler and Vogt (2013) who treat this taxon as a full species. This turtle species has the smallest distribution range within in the Yucatán Peninsula of any turtle species described here, occupying only the southwestern part of Campeche (though its complete range includes the coastal plain from central Veracruz and adjacent Oaxaca southeastern Tabasco, southwestern Campeche and Chiapas to northern Guatemala, southern Belize, and the extreme northwestern part of Honduras; see Legler and Vogt 2013). According to Lee (1996), *C. rossignoni* rivals *Dermatemys mawii* as the largest freshwater turtle in Mexico, attaining a carapace length of at least 47 cm and a mass of 20 kg. Based on observations, trapping, and information from fishermen, this species is not found in abundance anywhere (Legler and Vogt 2013). No information exists on the biology of this turtle for Campeche, thus we present data on its habitat, diet, reproduction and predation from other areas. In Veracruz and Chiapas this snapping turtle inhabits the marshy borders of shallow lakes and associated slow, meandering, muddy streams covered by water hyacinth; it does not appear to utilize the deep portions of lakes or inhabit large rivers, and basking is uncommon (Legler and Vogt 2013). Examinations of stomach contents of individuals from Veracruz suggest an opportunistic diet including small invertebrates (mostly crustaceans), fruits, seeds, and aquatic vegetation (Legler and Vogt 2013). In Chiapas Álvarez del Toro (1974) reported *C. rossignoni* feeding on hatchling crocodiles, and found that younger individuals feed on duckweed, aquatic invertebrates, and terrestrial invertebrates that fall into the water, as well as small fish and carrion. This turtle is known for its aggressive, pugnacious temperament; even hatchlings will attempt to bite when confronted (Legler and Vogt 2013). Limited observations and dissections suggest that females of *C. rossignoni* produce a single clutch of a massive number of eggs

(20–55) from April to July each year (Álvarez del Toro 1982; Legler and Vogt 2013). Álvarez del Toro (1974, 1982) reported that small individuals are consumed by *Staurotypus triporcatus*, *Crocodylus moreletii*, otters (*Lontra longicaudis*), and herons. Hatchlings are preyed upon by snakes of the genus *Drymarchon* (Ruthven 1912 in Legler and Vogt 2013). Adults are probably consumed only by crocodiles and humans (Lee 1996; Legler and Vogt 2013).

11.5 Lizards

With 45 species in 23 genera and 10 families, lizards are well represented in the Yucatán Peninsula. The Least geckos (genus *Sphaerodactylus*) are the smallest lizards known to occur in the area, reaching a maximum SVL of 25–30 mm. Least geckos are typical leaf litter inhabitants; they dart through the leaves, skillfully hunting small arthropods, such as springtails, cricket larvae and small spiders. Most gecko species are characterized by broadened adhesive lamellae beneath fingers and toes (allowing these animals to climb on smooth, vertical surfaces), as well as by the absence of moveable eyelids (their eyes are covered by a transparent membrane or "spectacle" instead). Some gecko species are crepuscular or nocturnal (e.g., *Hemidactylus* and *Phyllodactylus*), whereas others such as *Sphaerodactylus* are active during the day. Two species of Old World house geckos (genus *Hemidactylus*) have been introduced to the Yucatán Peninsula. These geckos are usually associated with human habitation. At night, they can be observed in houses, where they mainly prey on arthropods but also on small vertebrates such as smaller conspecifics. They are capable of vocalization; their call sounds like "gec-gec-gec." All gecko species in the region are oviparous, usually producing one or two eggs per clutch. In contrast to most other geckos, *Coleonyx elegans* (Fig. 11.1g) has moveable eyelids. This terrestrial nocturnal lizard hides beneath rocks and fallen tree trunks, and in hollow tree trunks during daytime. Its diet consists mostly of insects and spiders. The movements of this attractively patterned gecko are very graceful, almost cat-like. When alarmed, it expands its throat and assumes a stiff posture with the body held high, well off the ground.

At any given locality in the region, anoles are among the most common lizards and often several species of anoles occur together. Niche partitioning is evident in anoles, with different species found in bushes and lower parts of trees (e.g., *Anolis lemurinus*, *A. rodriguezii*, *A. sericeus*), on the trunks of large trees (e.g., *A. biporcatus*), or on the leaf litter (e.g., *A. tropidonotus*). One species, *A. beckeri*, even spends most of its time on twigs in the canopy, although it can also be observed also on the trunks of large trees. Most *Anolis* species have a brown to gray ground color, except for species such as *A. allisoni*, which is bright green when relaxed (Fig. 11.1h) but capable of rapid color change (metachrosis) to brown when stressed. Male anoles usually have large colorful dewlaps that are used during display behavior such as courtship and territorial defense. Displays consist of species-specific sequences of head bobbing with the dewlap extended. All anole species reproduce by laying eggs, and, during the breeding season, females will produce several clutches, each consisting of a single egg, at intervals of 1–2 weeks. The ovaries and oviducts on each side of the body are alternately active. For example, as soon as one egg is laid from the right oviduct, a new follicle is produced by the left ovary, which passes through the left oviduct, where it is fertilized and shelled within a few days, before being laid. In the meantime, the right ovary has produced a new follicle, which is ready to ovulate. As long as there is enough food available and weather conditions are suitable, this cycle will continue and females will lay eggs at regular intervals (Fitch 1982).

Three species of spiny-tailed iguanas (genus *Ctenosaura*) occur on the peninsula, with *C. similis* being the most common and largest—it can reach a total length of over 100 cm. While *C. similis* is mostly a ground dweller that also climbs on walls, roofs, and trees, the two smaller species endemic to the Yucatán Peninsula (i.e., *C. alfredschmidti* and *C. defensor*) have a largely arboreal lifestyle. However, because of the scarcity of trees with hollow branches in the rocky terrain of the northern Yucatán Peninsula, the beautifully colored *C. defensor* mostly uses limestone crevices as hiding places. All spiny-tailed iguanas lay eggs, with clutch sizes ranging from 2–12 (for smaller species) and 20–88 (*C. similis*). Suitable nesting sites for *C. similis* are open, sun exposed areas where females will dig a burrow to lay their eggs (Fitch and Hackforth-Jones 1983). The smaller species usually lay their eggs in the back portion of their hiding hole, typically a hollow branch or rock crevice. The eggs require an incubation of approximately 3 months (Köhler 2002). Hatchlings of *C. similis* are predominantly green in color with green markings. Spiny-tailed iguanas reach sexual maturity at 2–3 years of age.

The green iguana (*Iguana iguana*) is certainly the best-known lizard in Central and South America. The preferred habitat of this magnificent giant lizard is lowland forest, near streams, rivers, or lakes. While adult iguanas spend a lot of their time in the treetops, juveniles are often found closer to the ground in bushes. Green iguanas are impressive swimmers and divers, leaping into the water from as high as 10 m to escape predation. Green iguanas consume an almost exclusively vegetarian diet, consisting mainly of leaves. At the beginning of the dry season, the female will excavate a nesting site, which, depending on ground hardness, will be from 30 to 200 cm long (Rand 1968; Rand and Dugan 1983). Clutch size varies from 20 to 60 (rarely as many as 80) eggs, primarily depending upon the size of the female. The young will hatch following an incubation period of approximately 3 months, which usually corresponds to the onset of the rainy season. This ensures hatchlings a ready supply of tender leaves as nourishment.

Basilisks (genus *Basiliscus*), with head and dorsal crests that give them a truly dragon-like appearance, are among the most impressive and bizarre lizards of Central America. Their ability to run on their hind legs even across rapidly flowing water has earned them the local name “*Iguano Jesucristo*” (Jesus Christ Iguana). Two important adaptations that allow these animals to run on the water’s surface are broad fringes of skin on the toes, which distribute their body weight over a larger area, and the relatively heavy tail, which acts as a counter-balance to the upraised body during bipedal locomotion. These lizards are found in a number of habitats, wherever water in the form of streams, ponds, or swamps is present, and are quite abundant in many areas. Basilisks feed on insects, spiders, and small vertebrates, as well as occasional vegetable matter. Females basilisks produce three to seven clutches of eggs per season, each with 4–18 eggs, which hatch in 2–3 months (Köhler 1999).

Helmeted iguanas (genus *Corytophanes*) are relatives of the basilisks and are characterized by having a laterally flattened body and large occipital crests, or "helmets". Helmeted iguanas are tree-dwellers that spend most of their time in partial shade, waiting for their predominantly insect prey (Köhler 1999). Casquehead iguanas (genus *Laemanctus*) are remarkably well adapted for life in the trees, which they leave only to lay eggs. These iguanas are difficult to spot amongst the leaves. Several times a year, *Laemanctus* females will produce a clutch of four to nine eggs, which hatches after only 2 months (Köhler 1999).

In the dry regions of Mexico and Central America, next to spiny-tailed iguanas, spiny lizards (genus *Sceloporus*) are the dominant lizard group. In the Yucatán Peninsula, six species of *Sceloporus* are known to occur. Spiny lizards are diurnal small to mid-sized lizards, most of which are covered with extremely spiny scales. They feed on arthropods, as well as small vertebrates. Among *Sceloporus* species, some are ground-dwelling and saxicolous species, as well as primarily arboreal species (e.g., *S. lundelli*). The ground-dwelling *S. chrysostictus*, *S. cozumelae*, *S. teapensis*, and *S. variabilis* can frequently be seen on tree stumps or rocks. *Sceloporus serrifer* can be seen in great numbers at several archeological sites, although the animals are quite shy and will flee at the slightest disturbance. These attractive lizards bask on trees, as well as on rocks and brick walls, and will disappear into the nearest crack or opening when threatened. *Sceloporus* males are highly territorial and attempt to intimidate intruders with push up-like movements of their upper body. Most *Sceloporus* species in the region reproduce by laying eggs, with the exception of *S. serrifer*, which is viviparous (Köhler and Heimes 2002).

Several species of the Teiidae family occur in the Yucatán Peninsula, the Common Ameiva, *Holcosus undulatus* (formerly known as *Ameiva undulata*), being the largest. Five species of whiptails (genus *Aspidoscelis*) also belong to this group of fast diurnal lizards. To the human observer, these lizards seem tremendously restless, as they are in virtually constant motion. As heat-loving animals, ameivas and whiptails are out in the open primarily on hot, sunny days, whereas they retreat to their underground burrows when the sky is cloudy. Cool and rainy days are spent in burrows as well. Ameivas and whiptails are tenacious hunters that will wander around their territory looking for prey, scratching in the leaves, digging in the ground, and searching in the undergrowth and under bark, primarily consuming insects and arachnids. These lizards are constantly flicking their tongues, checking the scents in their surroundings. Although they are ground dwellers, these lizards will also climb trees and low vegetation to bask or to reach prey. Notably, several *Aspidoscelis* species, including *A. cozumela* and *A. rodecki* reproduce parthenogenetically. In these two species, the populations consist exclusively of females, which produce fertile eggs without any previous copulation—males are unknown in these two species (Köhler 2008).

The four species of the family Scincidae in the region are small to moderate-sized diurnal lizards with shiny, smooth scales and short limbs. They feed primarily on arthropods, but will also eat small vertebrates. These animals are generally found on the ground, but they will climb tree trunks in order to bask. *Mabuya unimarginata* is viviparous, with litter size varying from two to seven young. The other scincid lizards in the region are oviparous, producing clutches of one to three (seldom four) eggs (*Sphenomorphus cherriei*), or even up to 11 eggs per clutch (*Eumeces sumichrasti*). While adult *E. sumichrasti* have a pale brown color with black longitudinal stripes, young individuals are somewhat more brightly colored. The latter have a bright blue tail, and several orange spots on the head, as well as three orange to yellow longitudinal stripes on the body (Köhler 2008).

A single species of the family Anguidae occurs in the Yucatán Peninsula, *Celestus rozellae*. It is a diurnal tree-dweller that spends time at a considerable height above ground, but can also be observed basking on tree trunks only 50–250 cm above the ground (Lee 1996; McCranie and Wilson 1996). *Celestus rozellae* is viviparous, producing litters of three to five juveniles from May to July (Álvarez del Toro 1982).

Lepidophyma flavimaculatum (family Xantusiidae) is a bizarre-looking mid-size lizard (SVL to 95 mm) that has no eyelids. As with many gecko species, they possess so-called "spectacles". The sides of the body are decorated with countless, irregularly arranged tubercular scales, while the tail is equipped with whorls of slightly enlarged scales. During the day, these ground-dwelling lizards hide under rocks and fallen logs, which provide a moist microclimate. These nocturnal animals are sit-and-wait predators whose prey consists largely of insects and spiders. The remarkable thing about this genus is its viviparous method of reproduction with a fully developed placenta. There are also populations composed entirely of females that reproduce parthenogenetically. From April to July, the females of *L. flavimaculatum* bear two to five (seldom as many as eight) young, which have a SVL of 35–38 mm at birth (Álvarez del Toro 1960; Telford and Campbell 1970).

11.6 Serpentes

The known snake fauna of the Yucatán Peninsula consists of 55 species, encompassing 40 genera and six families. This count includes six venomous species, one of which is the elapid *Micrurus diastema*, while the other species are in the family Viperidae. *M. diastema*, the only venomous coral snake in the Yucatán Peninsula, is highly variable in its color pattern, from regularly tricolored individuals to almost uniformly red animals. In view of the highly potent neurotoxic venom of this species, extreme caution is advised in dealing with them. Coral snakes feed predominantly on other snakes, but will also eat eels and caecilians.

Five viperid species are known to occur in the region with three endemics, *Crotalus tzabcan*, *Porthidium yucatanicum* and *Agkistrodon russeolus* (Fig. 11.1i). The latter species is a small terrestrial inhabitant of thorn forest, tropical deciduous forest, and tropical semi-deciduous forest. It feeds on small vertebrates such as lizards, frogs, snakes, and mammals. The largest and most dangerous venomous snake in the region is *Bothrops asper*, which can reach a total length of more than 2 m. It lives not only in forested areas, but also in secondary undergrowth near human habitation, preferably close to water. There, this nocturnal pit viper will hunt frogs, lizards, and small mammals. All viperids in the region are live-bearing, producing litters of four to ten (*P. yucatanicum*) or even up to 86 (*B. asper*; usually 20–50), neonates (Solórzano and Cerdas 1989; McCoy and Censky 1992).

The small snakes of the families Typhlopidae and Leptotyphlopidae are represented by three species in the region, one of which (*Ramphotyphlops braminus*) is introduced. It is assumed that this small snake was transported from its native Southeast Asia, Australia, and the South Pacific, in potted plants. As it is parthenogenetic, only a single female is required to establish a new population (Nussbaum 1980). *Amerotyphlops microstomus* is endemic to the Yucatán Peninsula. This secretive burrower feeds mainly on termites, ants and other small insects.

The largest snake in the region is *Boa constrictor*. Although it is predominantly crepuscular and nocturnal, it is occasionally encountered outside of its hiding places during the day. Typical daytime hiding places include hollow trees, as well as piles of leaf litter among the buttress roots of large trees. Boas are not too particular about their vertebrate prey and will consume any lizard, bird, or mammal they can swallow. *B. constrictor* is viviparous and produces litters of 10–64 young (Köhler 2008).

With 45 species, the family Colubridae is well represented in the Yucatán Peninsula. For convenience, we have grouped these species according to their lifestyles, temperament, and size. These categorizations, of course, do not reflect phylogenetic relationships.

A large proportion of the snakes in the Yucatán Peninsula can be referred to as terrestrial diurnal racers. These are medium-sized to large, diurnal, mostly terrestrial, fast-moving, and easily irritated snakes such as *Conophis lineatus*, *Masticophis mentovarius*, *Mastigodryas melanolomus*, and *Drymobius margaritiferus*. These snakes have large eyes, reach more than 1 m in total length when adult (except for *C. lineatus* with adults in the 70–90 cm range), and feed mostly on small vertebrates such as frogs, lizards, and rodents. When caught or handled, these racers promptly deliver a bite. *Conophis lineatus* is a rear-fanged snake with a pair of greatly enlarged, erectile, grooved teeth in the posterior upper jaw and a mildly venomous secretion from its Duvernoy's glands, which are primitive venom glands situated posterior to the eyes. The clinical signs of a bite by *C. lineatus* can include severe pain at the bite site and local swelling. These racers are often seen crossing a trail or road before quickly disappearing into the vegetation. Although it is never a good idea to grab the tail of a snake, in the case of *D. margaritiferus*, the tail easily comes off because these snakes are capable of tail autotomy. In fact, a good proportion of individuals of this species have incomplete tails (Köhler 2008).

Another group of large snakes are the diurnal arboreal racers, which share similar characteristics to the species mentioned above, except that these are arboreal and therefore slenderly-built climbing species. Some of them are predominantly green in color such as *Leptophis ahaetulla*, *L. mexicanus*, and *Oxybelis fulgidus*. *Leptophis ahaetulla* is notorious for its irritable temperament. When handled, it will respond with a threatening gape, expanding the lower jaw, hence their Latin name. They will often remain in this pose for an extended period of time, but rarely make use of their numerous pointed teeth. It feeds primarily on frogs, as well as the occasional salamander, lizard, snake or bird egg (Oliver 1948; Sexton and Heatwole 1965). *Pseustes poecilonotus* lives primarily in old growth rainforest, where it can be found both on the forest floor, as well as in shrubs and trees. If it feels threatened, it will inflate its upper body, open its mouth wide and bite without hesitation. This large snake feeds primarily on birds, small tree-dwelling mammals, and bird eggs (Álvarez del Toro 1982; Campbell 1998). The large, green *Oxybelis fulgidus* and the smaller, gray to brown *O. aeneus* are both rear-fanged snakes, with mild venom that does not pose a serious threat to humans, but can lead to localized swelling and itching (Crimmins 1937). When a vine snake is handled, it will react with a threatening gape, exposing the blue-black interior of its mouth; it will also bite without any warning. As a defensive reaction, this colubrid will continuously hold its outstretched tongue rigid with the two tips of the tongue pressed together. A large part of their diet is made up of anoles (*Anolis*), but other lizards are also eaten along with frogs, rodents, birds and insects. *Spilotes pullatus* is extremely agile at moving through vegetation, thus its Spanish name, "*voladora*" (the flying one). It feeds primarily on small mammals, birds, and bird eggs (Henderson and Hoevers 1977; Lee 1996). All these arboreal racers have in common that they reproduce oviparously, producing clutches of 4–11 (*D. corais*), 3–5 (*O. aeneus*), 8–10 (*O. fulgidus*), 7–14 (*P. poecilonotus*), and 7–25 (*S. pullatus*) eggs, respectively (Goode 1989; Campbell 1998; Köhler 2005). *Drymarchon melanurus* is a fast, diurnal colubrid that feeds on a variety of vertebrates (e.g., fish, frogs, turtles, lizards, rodents, and small birds).

Several other diurnal snakes of small to moderate size occur in the Yucatán Peninsula, with *Coniophanes* being the most diverse genus in the area. The four species of these secretive, rear-fanged (opisthoglyphous), but usually inoffensive snakes are known to feed on frogs, salamanders, lizards, and snakes, as well as reptile and bird eggs; they will also consume invertebrates, such as earthworms and insect larvae (Minton and Smith 1960; Landy et al. 1966; Seib 1985; Platt and Rainwater 1998). The species of this genus are oviparous and lay 1–10 eggs per clutch, usually under rotting logs or roots (Campbell 1998). *Symphimus mayae* is a diurnal and semi-arboreal Yucatán endemic, inhabiting mostly dry areas. It is known to feed on insects (mostly crickets and grasshoppers) (Rossman and Schaefer 1974). The species is oviparous and produces clutches of two to four eggs during the wet season (Stafford 2005). *Stenorrhina freminvillei* is a harmless rear-fanged snake, which will not attempt to bite. As a nocturnal ground-dweller, it feeds almost exclusively on spiders and scorpions (Duellman 1963; Sexton and Heatwole 1965; GK pers. obs.) It is oviparous and produces clutches of four to nine eggs during the dry season (Censky and McCoy 1988).

Six species of snail-eating snakes occur in the Yucatán Peninsula, distributed among the genera *Dipsas* (*D. brevifacies*) (Fig. 11.1j), *Sibon* (*S. nebulatus*, *S. sanniolus*), and *Tropidodipsas* (*T. fasciatus*, *T. fischeri*, *T. sartorii*). The morphological adaptations that enable these snakes to pull their slimy prey out of their shells include particularly long teeth in the lower jaw and a conspicuously short snout. These are small to mid-sized, harmless colubrids that can be found at dusk and at night crawling around in vegetation, particularly during rain. They feed on snails and slugs, and have developed specific strategies to pull out the soft bodies of snails. Some hold the shell of the snail firmly in the coils of their body; others seek help of a Y-shaped twig as an anchor point (A. Hertz pers. comm.) The snake will grab the foot of the snail with the teeth of the lower jaw, press the shell against the upper jaw and then use the lower jaw to pull the soft body parts out of the shell. Up to a third of the snake's lower jaw is shoved into the shell during this procedure. After the snail is pulled out, the snake will drop the shell and swallow the soft body parts. Slugs are grabbed in the middle, pulled out of the substrate and usually swallowed tail first. All these species are oviparous and produce clutches of two to six eggs towards the end of the dry season or at the beginning of the rainy season (Kofron 1987; Campbell 1998).

Two species of Garter snakes (genus *Thamnophis*) occur in the region (i.e., *T. marcianus* and *T. proximus*). Garter snakes are semiaquatic, harmless snakes that will expel a vile-smelling secretion from the cloaca as their first line of defense before they will bite. They live in ponds, lakes, swamps, streams, and rivers, and feed on tadpoles, frogs, fish, and earthworms (Rossman et al. 1996). They are predominantly diurnal, but are occasionally also seen at night (Campbell 1998). All species are livebearers, producing litters of 6–22 young (Rossman et al. 1996).

Finally, there is a group of small, secretive, terrestrial colubrids with representatives in the genera *Ficimia, Ninia, Tantilla*, and *Tantillita*. These are without exception harmless snakes that will rarely attempt to bite when they are handled. They are most commonly found by turning over rotten logs or rocks in the forest, as well as in meadows. They feed on invertebrates, such as earthworms, beetle larvae, and centipedes (Van Devender and Cole 1977; Lee 1996; Campbell 1998).

11.7 Conservation

The principal threats to amphibians and reptiles in the Yucatán Peninsula are habitat loss/modification, pollution, overharvest for food and the pet trade, exotic species, infectious diseases, and climate change (Duellman 1999; Whitfield-Gibbons et al. 2000; Köhler 2011). Among the 142 species of reptiles and amphibians present in the states of Campeche, Yucatán, and Quintana Roo, 18 (13 %) appear as endangered (i.e., as Near Threatened and higher categories) in the Red List

Table 11.3 Number (%) of species of amphibians and reptiles listed in an endangered category (i.e., near-threatened and above) or appendix of the IUCN red list, CITES and Mexican NOM-59-SEMARNAT-2010

Groups	Orders	IUCN	CITES	NOM
Reptiles	Crocodilia	1 (50)	2 (100)	2 (100)
	Testudines	12 (75)	7 (43.8)	14 (87.5)
	Squamata			
	Sauria	3 (6.8)	1 (2.3)	18 (40.9)
	Serpentes	1 (1.8)	3 (5.4)	18 (32.1)
	Total	17 (14.4)	13 (11.0)	52 (44.1)
Amphibians	Caudata	0 (0)	0 (0)	3 (100)
	Anura	1 (4.8)	1 (4.8)	5 (23.8)
	Total	1 (4.2)	1 (4.2)	8 (33.3)
Total		18 (12.7)	14 (9.9)	60 (42.3)

of threatened species of the International Union for the Conservation of Nature (IUCN). Fourteen (9.9 %) appear in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and 60 (42 %) are listed as threatened species under Mexican law (NOM-059-SEMARNAT-2010) (Table 11.3). Of the 18 species appearing as endangered in the IUCN Red List, eight are listed as Near Threatened, five as Vulnerable, two as Endangered, and three as Critically Endangered. The three critically endangered species are the freshwater Central American river turtle (*Dermatemys mawii*), the Hawksbill Turtle (*Eretmochelys imbricata*) and Kemp's Ridley turtle (*Lepidochelys kempii*). Among the 14 species appearing in the CITES appendices, six are listed in Appendix I (*Crocodylus acutus* and the five sea turtles), another six appear in Appendix II (*Crocodylus moreletii*, *Dermatemys mawii*, *Terrapene carolina*, *Iguana iguana*, *Boa constrictor*, *Agalychnis callidryas*), and two appear in Appendix III (*Micrurus diastema* y *Crotalus simus*). Of the 60 species listed by the NOM-059-SEMARNAT-2010, 41 appear with the status of Under Special Protection, ten are Threatened and nine Endangered. The nine endangered species are the five sea turtles, the freshwater turtles *Dermatemys mawii* and *Claudius angustatus* and the lizards *Ctenosaura defensor* and *Aspidoscelis rodecki*.

Habitat loss and degradation are the main factors driving the decline of both amphibian and reptile populations (Whitfield-Gibbons et al. 2000; Köhler 2011). Populations of coastal species are particularly vulnerable to these threats because of a higher rate of modification and destruction of coastal habitat. This is due to accelerated urban development along the Caribean coast of the Yucatán Peninsula, accompanying the mass tourism occurring in Quintana Roo. Coastal habitats of the Yucatán Peninsula are important for a great number of species of amphibians, lizards, freshwater and marine turtles, snakes and crocodiles, including endemic species such as *Sceloporus cozumelea* and *Aspidoscelis rodecki* (Escobedo-Galván et al. 2011). Populations of the latter species are restricted to a small area in northern Quintana Roo where urban development is increasing, and the destruction of its remaining habitat could drive this endemic species to extinction. Development-associated loss of vegetation cover involves increased soil temperature, reduced connectivity among subpopulations, and decreased availability of food/prey, refuges and reproduction sites, among other factors. Reptiles are ectotherms that depend on the ambient temperature for many aspects of their biology, ethology and physiology; thus, changes in temperatures could lead to important impact on coastal reptile populations. Concerning connectivity loss, the fragmentation of Quintana Roo's coastal habitat is the major threat to the recovery of the American crocodile, which presents high rates of inbreeding (Machkour M'rabet et al. 2009). Furthermore, these populations of *Crocodylus acutus* show high levels of hybridization and introgression with *C. moreletii*, especially in the southern coastal areas, which could lead to local extinctions of small, isolated, genetically pure populations (Rhymer and Simberloff 1996; Cedeño-Vázquez et al. 2008; Machkour M'rabet et al. 2009). However, island populations remain genetically pure and conservation efforts are needed in these islands to preserve the last reservoirs of *C. acutus* (Machkour M'rabet et al. 2009). Moreover, the modification of beaches, coastal dunes and nearby brackish lagoons due to tourist development is reducing the potential area for nesting sites and nursery habitat of marine turtles and crocodiles (Platt and Thorbjarnarson 2000; Escobedo-Galván et al. 2011). The increased human colonization of crocodile habitat could also lead to increased crocodile/human encounters, which generally end with the death of crocodiles (Escobedo-Galván et al. 2011). The number of crocodile attacks on humans in Quintana Roo increased between 2005 and 2011, after almost a decade without incidents (Charruau et al. 2012).

The increase in urban and agriculture areas in the Yucatán Peninsula also raises the level of environmental pollution by chemicals or plastic debris, which have adverse effects in amphibians and reptiles. While amphibians have been the subjects of many ecotoxicological studies, reptiles have received little attention; most studies on contaminant effects have focused on turtles and crocodiles (Whitfield-Gibbons et al. 2000; Gardner and Oberdörster 2005). Reptiles are particularly sensitive to organochlorine pesticides, which are endocrine system disruptors and can cause severe abnormalities such as sex reversal, feminization of males and lowered reproductive success (Guillette and Milnes 2000). Heavy metals and polychlorinated biphenyls (PCBs) can also cause abnormalities in reptiles and amphibians (Gardner and Oberdörster 2005; Gonzalez-Jauregui et al. 2012; Adlassnig et al. 2013). In the Yucatán Peninsula, the few studies on ecotoxicology in herpetofauna have shown the presence of organochlorine pesticides, PCBs, and heavy metals, which have been detected in crocodile eggs and tissues, and also in sea turtle eggs (Cuevas et al. 2003; Gonzalez-Jauregui et al. 2012; Charruau et al. 2013; Buenfil-Rojas et al. 2015). PCBs affect the testosterone levels in female *C. moreletii* (Gonzalez-Jauregui et al. 2012). Although a case of amelia that could be due to contamination has recently been observed in *C. moreletii* (Charruau and Niño-Torres 2014), no other effects of contamination on the herpetofauna have been detected in the Yucatán Peninsula. Plastic debris is also a serious threat to amphibians and reptiles, either by ingestion or entanglement (Gregory 2009).

Entanglement in a polyvinyl chlorine ring by *Ctenosaura similis* has been observed (Fig. 11.1k) on the atoll of Banco Chinchorro, as well as the regurgitation of 85 plastic bags weighing a total of 5 kg by an American crocodile in the Nichupté lagoon in Cancun (J. Carballar-Osorio pers. comm.)

Introduced species affect native species through competition, predation, disease transmission, habitat modification, and alteration of the trophic structure (Pitt et al. 2005; Bucciarelli et al. 2014). Some invasive reptiles and amphibians are known to affect species of their own group (Pitt et al. 2005; Bucciarelli et al. 2014). As mentioned previously, four species of reptiles and one species of amphibians have been introduced in the Yucatán Peninsula. These species are *Hemidactylus frenatus* (Fig. 11.1l), *H. turcicus*, *Anolis sagrei,* and *Rhamphotyplops braminus* for reptiles and *Eleutherodactylus planirostris* for amphibians. *E. planirostris* is a highly successful invasive species that was recently detected in Playa del Carmen, Quintana Roo (Cedeño-Vázquez et al. 2014). *Hemidactylus* spp. and *A. sagrei* are known successful invasive species and are well established in the Yucatán Peninsula (Case et al. 1994; Lee 1996; Campbell 1999; Echternacht 1999; Cole et al. 2005; Dame and Petren 2006). However, other introduced invasive vertebrates (e.g., janitor fish, tilapias, rats, feral pigs), invertebrates (e.g., fire ants) and plants (e.g., sheoak *Casuarina equisetifolia*) present in the peninsula could threaten native species of amphibians and reptiles (Whitfield-Gibbons et al. 2000).

Certain diseases can seriously affect species of reptiles and amphibians, causing population decline and potentially species extinction (Whitfield-Gibbons et al. 2000; Köhler 2011). The chytrid fungus *Batrachochytrium dendrobatidis* is causing a wave of extinction of amphibians in different parts of the world and is present in the state of Chiapas, near the Yucatán Peninsula (Lips et al. 2004). Another disease, fibropapilloma (Herbst 1994), is a viral tumor-causing disease that can potentially kill loggerhead sea turtles, as the tumors grow and inhibit movement, feeding, and vision. It has yet to be been detected on the peninsula, but due to the wandering behavior of sea turtle species it is likely only a matter of time before it arrives. Parthenogenetic species, such as the lizards *Aspidoscelis cozumela* and *A. rodecki* are more vulnerable to disease, as all individuals are females and share the exact same genome (Taylor et al. 2014).

Global climate change is a major threat to herpetofauna in the peninsula, through potentially increasing intensity and frequency of tropical cyclones, alterations of rainfall and temperatures patterns and increasing sea levels (Michener et al. 1997; Whitfield-Gibbons et al. 2000; Webster et al. 2005). Hurricanes and tropical storms are frequent in the Yucatán Peninsula and an increase of the number of category 3, 4 and 5 hurricanes has been observed over the last decades, while tropical storms and category 1 and 2 hurricanes have decreased (Charruau 2010). These cyclones destroy extensive areas of reptiles and amphibians habitat, resulting in the same changes described in the paragraph on habitat loss. A key impact of tropical storms is the destruction of turtle and crocodile nests (Michener et al. 1997; Charruau et al. 2010a). One study on the effects of tropical storms on American crocodiles nesting in Quintana Roo showed that hurricanes dramatically reduced nesting success by cooling and flooding clutches (Charruau et al. 2010a). However, it is likely that heavy rainfall from tropical cyclones can benefit hatchling survival by decreasing salinity in hypersaline nurseries. Tropical cyclones have negative short-term impacts on crocodile nesting but likely have an overall beneficial effect by creating and maintaining open sandy nesting areas used by crocodiles (Charruau et al. 2010a). However, rapid sea level rise would cause a reduction of coastal habitat including nesting sites of turtles and crocodiles. This would especially affect species that are only distributed on the coast and are already declining such as the endemic *Aspidoscelis rodecki*.

Scenarios of climate change in the Yucatán Peninsula predict an increase in temperature and a decrease in rainfall for the year 2020 (Orellana et al. 2009). Changes in rainfall and temperature patterns would affect amphibians and reptiles because of their tight dependence on these parameters. A change in temperature regime is also likely to affect reptiles with temperature-dependent sex determination (TSD), where the sex of embryos is determined by the incubation temperature and not by sexual chromosomes (Valenzuela and Lance 2004). An increase in nest temperature of TSD species could cause highly biased sex ratios, and affect population survival (LeGalliard et al. 2005). The crocodiles and several species of lizards and turtles in the Yucatán Peninsula that show this type of sex determination could be affected (Valenzuela and Lance 2004; Charruau 2010, 2012). Moreover, incubation temperature determines many physiological and morphological characteristics in amphibians and reptiles that are important for the survival of individuals and thus of their populations (Valenzuela and Lance 2004). Thus, the alteration of temperature and rainfall patterns in the peninsula in the near future is likely to have an important impact on the herpetofauna.

The illegal or unsustainable use of species, which includes illegal hunting, capture, collection, and transport of specimens, may also threaten some species of amphibians and reptiles (Whitfield-Gibbons et al. 2000). Although no study exists on the level of this threat in the Yucatán Peninsula, data on wildlife use and hunting (including data on reptiles) have been recorded in rural communities of the peninsula (Lee 1996; Santos-Fita et al. 2012). One example of the consequences of unsustainable use of a reptile in the Yucatán Peninsula is the case of the American crocodile. This species was highly over-exploited for its skin from the beginning to the middle of the twentieth century. Populations remain depleted in most areas, and show a difficult recovery in current conditions of global change (Cedeño-Vázquez et al. 2006b). Opportunistic killing of crocodiles is still occurring in the peninsula, and although it is difficult to assess the number of killings, the loss of even a few individuals, especially adult females, can have a dramatic impact on the depleted and fragmented populations of *C. acutus* in the peninsula (Cedeño-Vázquez et al. 2006b).

One option for the herpetofauna to adapt to changes in habitat modification is shifting their distributional range. However, amphibians and reptiles have a limited ability to disperse, and the destruction, fragmentation and modification of their habitat further reduces their dispersal ability.

Regarding conservation measures, major efforts have focused on sea turtles (Calderón-Mandujano and Cedeño-Vázquez 2011; Herrera-Pavón 2011). Although some conservation programs exist locally for crocodiles in the northern portion of the peninsula, the major conservation strategy for the herpetofauna is the declaration of protected natural areas (Cedeño-Vázquez and Calderon-Mandujano 2011; Calderón-Mandujano and Cedeño-Vázquez 2011). The peninsula hosts 45 protected natural areas (25 federal, 16 state reserves and four municipal reserves), some of them ranking among the largest protected areas in the country. The principal protected areas are Laguna de Terminos, Calakmul, Los Petenes, Sian Ka'an, Ría Lagartos and Ría Celestun. Calakmul Biosphere Reserve is preserving 723,185 ha of tropical forest in the south-center of the peninsula, while the other reserves are coastal and located all around the peninsula. The 45 reserves together cover an area of 4,838,553 ha which represent 34.2 % of the total area (14,136,157 ha) of the Yucatán Peninsula.

11.8 Perspectives

The diversity of amphibians and reptiles is relatively well known in the Yucatán Peninsula (Lee 1996; Köhler 2008, 2011), but knowledge on the ecology of the species remains scarce. For instance, the majority of the studies on turtles has been centered on the marine species, and conducted in the state of Quintana Roo (e.g., Isla Contoy, Isla Mujeres, Cozumel, X'Cacel, and other coastal zones from La Riviera Maya, Sian Ka'an Biosphere Reserve, and Costa Maya). Most of our knowledge comes from studies conducted on post-nesting females because these turtles are relatively easy to capture and tag. Topics that have been addressed about marine turtles to date in the peninsula include conservation and management (Viveros-León 1991; Zurita et al. 1993; Herrera-Pavón and Zurita 2005; Ortiz de Montellano 2010), reproduction (Prezas-Hernández 1991; Espinosa 1992; Pérez-Castañeda et al. 2007), feeding ecology (Plotkin et al. 1993), interactions (Sentíes-Granados et al. 1999; Cárdenas-Palomo and Maldonado-Gasca 2005), phylogeography, the population's genetic structure (Bowen et al. 1992; Encalada et al. 1996, 1998) and toxicology (Talavera-Sáenz 2010). Crocodiles are the most studied reptiles in the Yucatán Peninsula. However, studies have been mainly carried out in the state of Quintana Roo, and little work has been done on crocodiles in other regions of the peninsula. Studies to date have dealt with species morphology and distribution, population status and ecology, reproductive ecology, maternal behavior, population genetics (including hybridization), toxicology, health, archaeology and ethnozoology (Cedeño-Vázquez et al. 2006b; Machkour M'rabet et al. 2009; Charruau 2011; Thurston 2011; Zamudio-Acedo et al. 2011; Charruau et al. 2010a, b, 2012; Charruau and Hénaut 2012).

Future studies on the herpetofauna in the peninsula should focus on the determination of their ecological needs for reproduction, feeding and thermoregulation, among other issues. Studies on factors threatening the region's herpetofauna are urgent given the current conditions of global change, and coastal species are likely the most threatened due to accelerated development in coastal areas.

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