**Reptiles**

Reptiles (Reptilia) are a class of vertebrates roughly comprising 11,570 species that live in a variety of climatic zones and terrestrial and aquatic habitats (Uetz 2021). They can be classified into four orders, the two largest being turtles and Squamata (scaled reptiles, which include lizards and snakes). Israel has 97 reptile species (Meiri et al. 2019), a high number relative to the country’s size. This diversity is due to Israel’s geographical location as a meeting point between three continents (Africa, Asia, and Europe) and several different zoogeographical regions (Mediterranean, Irano-Turanian, Sharo-Arabian, and Ethiopian).

Reptiles have two main characteristics: the keratinous scales that cover their bodies, and being poikilothermic (commonly and incorrectly termed “cold-blooded”), that is, they regulate their body heat through behavior changes over the course of the day and depending on the season.

Reptilian species that live in shifting sands have developed adaptations to the limiting factors typical of sand dunes (lack of available water, high temperatures in the dunes’ upper layer and the unstable shifting sand substrate). The reptiles cope with the limited water resources by having no sweat glands, utilizing fluids from food, reducing water volume in urine, and avoiding panting. The keratin that makes up the scales covering their body is an insoluble protein resistant to high temperatures. Behavioral characteristics that help these reptiles deal with high ambient temperatures and hot ground surfaces include avoiding activity during the hot hours, hiding in burrows or being partially buried in the sand, raising their body above the sand, and being active in the shade. Burrowing in the sand and adapting to breathing in the sand, sidewinding on sandy surfaces (in some snake species, see Photo 30), and enlarging the surface area of their limbs and bellies to prevent energy waste during movement are behaviors that help reptiles move through the unstable shifting sand.



Picture 30: *Acanthodactylus scutellatus* and *Lytorhynchus diadema* burrowing into the sand (Photo: Boaz Shaham).

In general, plants and animals that inhabit sand dunes are divided into two main groups: species with a high affinity to shifting dunes that are adapted to sandy habitats (psammophiles) and adaptive species (generalist species). The same is true for reptiles inhabiting the coastal dunes of Israel. For some species, the sandy areas along Israel’s coastal plain are the northernmost edge of their range (e.g., *Spalerosophis diadema*; Photo 31). A number of rare species (e.g. *Macroprotodon cucullatus*; Photo 31) are also found in the region. There is only a single endemic species inhabiting Israel’s coastal plain, the lizard *Acanthodactylus schreiberi syriacus* (Photo 32). Its taxonomy is controversial, but it is clear at least that it is a subspecies endemic to the sandy soils and sandstone of the coastal plain, from the Gaza Strip to the shores of Southern Lebanon.

The distribution pattern of psammophilic reptiles in Israel’s coastal sands is interesting compared to their distribution patterns in other sandy areas in Israel (a map can be found in Appendix A). The Western Negev has 13 highly psammophilic species, most of them of Saharan origin; seven of them are also found in coastal plain dunes. The distribution pattern indicates that these species “migrated” over time in the wake of shifting sand, from its source in the Nile Delta to the southwest and northward along the coastal plain of the Sinai Peninsula and Israel. In addition to these 13 species, two more species with affinity to desert habitats (not necessarily to sandy areas) are also found on Israel’s coastal plain, but in this case only in sandy habitats: *Stenodactylus sthenodactylus* and *Spalerosophis diadema* (Photo 31). Another species not limited to sandy habitats, but which thrives in them nonetheless, is *Psammophis schokari* (Photo 31).

When traveling northward along the coastal plain, the number of psammophilic or desert species declines and the number of generalist species in the assemblage of reptile species grows. The northernmost distribution limit of some of these species used to be the Yarkon River; today, however, due to accelerated development in this area, the northernmost limit shifted south of the Tel Aviv metropolitan area, to the remains of the sand dunes of Holon and Rishon LeZion. This is now the northernmost limit of the *Acanthodactylus scutellatus* lizard (Photo 32), the *Lytorhynchus diadema* (Photo 31), and the *Varanus griseus*, snakes (Boaz Shacham oral report; Photo 32). The northern part of the Nitzanim dunes (south of Ashdod) is the northernmost distribution limit of the *Macroprotodon cucullatus* snake and *Mesalina olivieri* lizard. The sand dunes of Netiv HaAsarah are the northernmost distribution limit of the *Acanthodactylus aegyptius* lizard (Shacham and Ben-David 2019).

Along the coastal plains, 37 terrestrial reptile species have been found (Perlberg et al., Boaz Shacham oral report). In the Nitzanim sand dunes, 23 terrestrial reptile species were found in all different types of dunes: 12 lizard species, ten snake species and one turtle species. About a third of these species have a desert habitat distribution, while the rest are defined as adaptive species and are common in a wide variety of habitats (Table 12). The highest number of desert species is found in the shifting dunes, and it decreases as the dunes stabilize (Shacham 2010).

*Macroprotodon cucullatus Spalerosophis diadema*

*Lytorhynchus diadema Psammophis schokari*

* *

*Stenodactylus sthenodactylus Sphenops sepsoides*

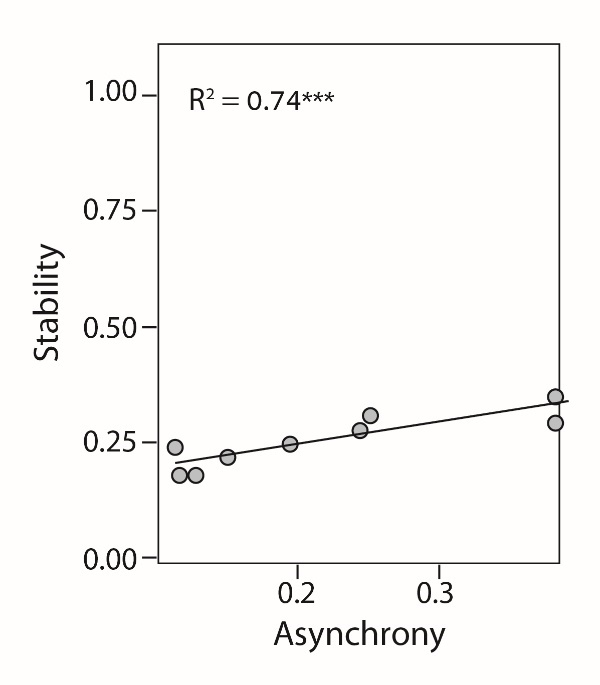
**

*Chalcides ocellatus*

**Photo 31:** (a) Desert reptile species found on coastal plain dunes: *Spalerosophis diadema, Macroprotodon cucullatus, Psammophis schokari, Lytorhynchus diadema, Chalcides sepsoides* and *Stenodactylus sthenodactylus* (photo: Boaz Shacham); (b) generalist species: *Chalcides ocellatus* (photo: Oz Ritner)

Six of the 23 species found in the Nitzanim sand dunes are very common. Of them, four are desert habitat species: *Chalcides sepsoides* skink, *Stenodactylus* *sthenodactylus* gecko, *Acanthodactylus scutellatus* lizard and *Lytorhynchus diadema* snake (Photos 31 and 32, Table 13); and two generalist species: *Chalcides ocellatus* skink (Photo 31) and *Acanthodactylus schreiberi syriacus* lizard. *A. scutellatus* lizard is common mainly in shifting and semi-fixed dunes, while *A. schreiberi syriacus*, *C. ocellatus*, and *L. diadema* are more common in semi-fixed and fixed dunes. Two species, *C. sepsoides* and *S. sthenodactylus*, are similarly found in all dune stabilization levels (Shacham 2010). In coastal plain sands, 14 species were found on shifting dunes and 23 species were found on semi-fixed and fixed dunes, with some of them also found on shifting dunes.

From analyzing the data collected over the years, it appears that the reptile communities (numbers and composition of species) are not affected by the percentage of vegetation cover on the dunes, as compared with other groups of organisms examined (annual plants, arthropods, and rodents). The temporal stability of reptile communities is affected by species asynchrony (Figure 27). Most species of reptiles are generalists, but it is possible that each species, or at least some of them, may have a niche that does not depend on the fixation level of the dune.



**Figure 27:** Temporal stability of reptile communities as a function of asynchrony (Bird et al. 2021)

**Table 12:** Reptile species found in the Nitzanim Dunes Reserve and their incidence (percentage of the observations in which the species is present out of all the observations made in dunes of the same stabilization level) for each of the dune stabilization levels: shifting, semi-fixed and fixed (Shacham 2010)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Common name** | **Scientific name** | **Distribution** | **Frequency found in shifting dunes (%)** | **Frequency found in semi-fixed dunes (%)** | **Frequency found in fixed dunes (%)** |
| Wedge-snouted skink | *Chalcides sepsoides* | Desert | 91 | 96 | 100 |
| Elegant or short- fingered gecko | *Stenodactylus sthenodactylus* | Desert | 94 | 98 | 93 |
| Ocellated skink | *Chalcides ocellatus* | Generalist | 30 | 80 | 80 |
| Schreiber’s fringe-fingered lizard | *Acanthodactylus schreiberi syriacus* | Generalist | 15 | 73 | 95 |
| Nidua fringe-fingered lizard | *Acanthodactylus scutellatus* | Desert | 97 | 88 | 7 |
| Crowned leafnose or diademed sand snake | *Lytorhynchus diadema* | Desert | 42 | 76 | 63 |
| False smooth snake | *Macroprotodon cucullatus* | Desert | 24 | 41 | 39 |
| Diadem or royal snake | *Spalerosophis diadema* | Desert | 12 | 39 | 41 |
| European or Eurasian blind or worm snake | *Xerotyphlops vermicularis* | Generalist | 9 | 37 | 37 |
| Schokari sand racer | *Psammophis schokari* | Desert | 12 | 27 | 20 |
| Bridled mabuya or bridled skink | *Heremites vittata* | Generalist | 0 | 8 | 37 |
| Greek or spurred thighed tortoise | *Testudo graeca* | Generalist | 3 | 12 | 15 |
| Palestine viper | *Daboia palaestinae* | Generalist | 0 | 10 | 20 |
| Rüppell’s snake-eyed skink | *Ablepharus rueppellii* | Generalist | 0 | 8 | 15 |
| Common or Mediterranean chameleon | *Chamaeleo chamaeleon* | Generalist | 12 | 4 | 10 |
| Javelin sand boa | *Eryx jaculus* | Generalist | 0 | 2 | 17 |
| Eastern Montpellier snake | *Malpolon insignitus* | Generalist | 0 | 2 | 17 |
| Black whipsnake | *Dolichophis jugularis* | Generalist | 0 | 4 | 5 |
| Kotschy’s gecko | *Mediodactylus kotschyi* | Generalist | 0 | 4 | 5 |
| Olivier’s sand lizard | *Mesalina olivieri* | Generalist | 3 | 4 | 0 |
| Pallas's glass lizard, European legless lizard, or European glass lizard | *Pseudopus apodus* | Generalist | 0 | 2 | 5 |
| Red whip snake or collared dwarf racer | *Platyceps collaris* | Generalist | 0 | 0 | 2 |
| Desert monitor | *Varanus griseus* | Desert | 0 | 2 | 0 |

**Table 13:** Distribution, main food, activity times, length, state of conservation and other details for psammophilic reptile species important for nature conservation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Common name** | **Distribution in Israel** | **Distribution along the coastal sands** | **Main food source** | **Activity time** | **Maximum length (cm)** | **Conservation status** | **Other details** |
| Wedge-snouted skink | Coastal sands, Negev and Arava | From Bonim Beach to Nitzanim Sand Dunes | Insects | Nocturnal | 17 | NT (near threatened) | Obligatory Psammophile. Usually found under the sand surface |
| Elegant or short-fingered gecko | Coastal sands, Negev, Judean Desert, Jordan Rift Valley | Along the entire coast | Insects | Nocturnal | 10 | LC (least concern) | Psammophile only on coastal sands |
| Schreiber’s fringe-fingered lizard | Coastal sands | From Achziv Beach to the Gaza Strip | Insects | Diurnal | 29 | CR (critically endangered) | Endemic (coastal sands, Northern Sinai, Southern Lebanon) |
| Nidua fringe-fingered lizard | Coastal sands, Western Negev | From Rishon LeZion sand dunes and southward | Insects | Diurnal | 21 | NT (near threatened) | Obligatory Psammophile |
| Crowned leafnose or diademed sand snake | Southern coastal sands, Negev, Arava | From Rishon LeZion sand dunes and southward | Lizards | Nocturnal | 50 | NT (near threatened) | Obligatory Psammophile |
| False smooth snake | Coastal sands, Western Negev | From the Ashdod sand dunes to the Gaza Strip | Small mammals and lizards | Nocturnal | 55 | LC (least concerned) | Rare. Endemic to the Mediterranean Basin |
| Diadem or royal snake | Southern coastal sands, Negev, Judean Desert | From Rishon LeZion sand dunes and southward | Rodents | Nocturnal during the summer and diurnal during the winter | 150 | LC (least concerned) | The Coastal sands are its northernmost distribution. Psammophile only on the coastal sands |
| Desert monitor | Southern coastal sands, Negev, Dead Sea Basin | Rishon LeZion, Palmachim and Nitzanim sand dunes | Rodents, mollusks, insects, tortoises, lizards | Diurnal | 150 | NT (near threatened) | The only hibernating lizard in Israel |

Characteristic lizards of Israel’s sand dunes

*Acanthodactylus scutellatus* and *Acanthodactylus schreiberi syriacus* are two characteristic lizards of the coastal sand dunes. Their distribution and interrelationships are interesting both on a regional and local scale. The subspecies *A. schreiberi syriacus* is endemic to the region from the coast of Lebanon in the north, along the Israeli coast and the Gaza Strip in the south. The *A. schreiberi syriacus* lizard is found in the sand dunes of North Africa, Saudi Arabia, and Israel.

Only the *A. schreiberi syriacus* lizard is found in the Northern Tel Aviv sand dunes. This is the only lizard in the region that inhabits dunes, and it can be found in dunes at all levels of stabilization: shifting, semi- fixed and fixed dunes. Its level of activity and foraging strategies are the result of a combination of two factors: the amount of food (mainly various arthropods; Table 13), which increases with the increase in vegetation cover, and the risk of predation, which also increases with the increase in food. Renan (2010) and Renan and Buskila (2010) found that in shifting dunes, where the amount of food is low and, consequently, the number of predators is low, the *A. schreiberi syriacus* lizard’s level of activity in open areas is the highest, and it forages actively for prey. In semi-fixed dunes, where there is much food and, consequently, a greater relative number of predators, the level of activity drops sharply. Since food is in relative abundance, the *A. schreiberi syriacus* lizard tends to lay in wait for its prey to avoid predation. In fixed and semi-fixed dunes, the *A. schreiberi syriacus* lizard’s level of activity is similar. Since the amount of food is abundant, it returns to active foraging in open paths between shrubs for very short periods of time.

Two species of *Acanthodactylus* lizards inhabit the Nitzanim sand dunes: the *A. schreiberi syriacus* lizard is common in fixed dunes, while the *A. scutellatus* lizard, a species with a high affinity for shifting dunes (an obligate psammophile), is primarily common in shifting dunes. In years with average climatic conditions and relative food abundance, both species of *Acanthodactylus* lizards can be found together in the same habitat with different frequencies, sharing resources in various ways. However, during dry years, when food is scarce, the *A. scutellatus* lizard has an advantage over the *A. schreiberi syriacus* lizard due to its adaptation to drought. Therefore, the latter will be found predominantly in fixed dunes, while the former will be found in shifting or semi-fixed dunes (Avital 1981). Consequently, in the southern coastal plain dunes, these two species serve as good indicators of food availability and, presumably, dune stability level. The *A. scutellatus* lizard is characteristic of shifting dunes, and when they become vegetated and fixed, the *A. schreiberi syriacus* lizard replaces the *A. scutellatus* lizard in the fixed dunes (Shacham 2010).

Lizard species, like many other animals, spend considerable time foraging for food. This activity consumes energy and exposes them to predation. The evolutionary drive for efficiency in energy expenditure (minimal investment in searching for food alongside a large energy gain obtained from food) has led to the development of various behavioral patterns, cryptic coloring, selection of suitable habitats, and more (Lima 1998). Animals needs to balance their activity level in food foraging, the method of foraging, and the selection of the best foraging sites to increase their chances of survival (Hawlena 2009; Cooper & Whiting 1999; Werner et al. 1990). At the same time, they must learn how to avoid predators or minimize exposure to them (Hawlena 2009; Zahavi & Zahavi 1999).

Renan (2010) examined the foraging behavior of the *Acanthodactylus schreiberi syriacus* lizard in relation to the risk of predation in the dunes of Caesarea and Nitzanim. She found that the activity level and duration of stay in open areas of shifting dunes were significantly higher than the activity level and duration of stay in open patches of semi-fixed dunes, and even more so in the fixed dunes. The availability of insects, which the *A. schreiberi syriacus* lizard feeds on, was much lower in the shifting dunes compared to the more fixed dunes (Renan 2007; Ramot 2007), resulting in longer time spent foraging for food (Reichmann 1998). In the shifting dunes, where vegetation cover is low and food availability is low, the risk of predation is also lower compared to the fixed dunes, where vegetation cover is high and food is abundant (Boochnik 2001). Therefore, in the shifting dunes of Caesarea, the *A. schreiberi syriacus* lizard is more active in open areas, where it lies in wait for its prey and waits to catch it, while positioned at the burrow entrance or beneath a shrub. In contrast, in the fixed dunes, the duration of activity in open areas is shorter, and the *A. schreiberi syriacus* lizard hunts for its food while in motion. In the Nitzanim sand dunes, where the *A. scutellatus* lizard is very common in shifting dunes, the *A. schreiberi syriacus* lizard will partially prefer the fixed dunes due to the abundance of food and absence of competition to compensate for the higher risk of predation. Additionally, the activity level of the *A. schreiberi syriacus* lizard in the Nitzanim sand dunes is higher than in Caesarea’s dunes. This may be due to the different makeup of arthropods and insects between the two sites (Renan 2007), or due to differences in their abundance. Young *A. schreiberi syriacus* lizards are more active and spend significantly more time in open areas, but their foraging behavior does not differ from that of the adults.

In the *Chalcides sepsoides* skink population, Shacham (2010) found evidence of a trade-off between the risk of predation and predation success. This depends on the characteristics of different habitat types in the sand dunes. The frequency of tail breaking or its regeneration in this population is an indicator of predation risk. The data shows that as the landscape becomes more exposed (shifting sand dunes), the rate of tail injuries is higher in this species, indicating a higher risk of encountering a predator. Concomitantly, as the landscape becomes more exposed, the physical condition of the *Chalcides sepsoides* skink is better (according to calculations of body mass index). In other words, there is a noticeable trade-off here between taking a higher risk in exchange for a potentially greater accumulation of body mass, probably due to reduced intraspecific competition for food.

In the southern coastal plain sand dunes, there remain very small populations of the desert monitor (*Varanus griseus*), one of the largest and most impressive lizards in Israel. It is considered an apex predator in the dune ecosystem. The *V. griseus* is a diurnal and thermophilic lizard. Thus, its activity is limited to the summer months. It is not often seen, but its tracks are very noticeable. This species is included in Israel’s highly endangered (red) list of species.

In surveys conducted in recent years (Shacham and Ben-David, 2019; Ben-David et al., 2020) that assess the species abundance (number of individuals) in the southern coastal plain sand dunes, a significant correlation was found between the presence of the *V. griseus* and off-road vehicle activity, vegetation cover level, and the extent of the sandy “island” area. The highest number of desert *V. griseus* was found in the sand dunes of Firing Range 24 (Rishon LeZion sand dunes) and in the Palmachim Sand Dunes Nature Reserve, both of which are areas used by the Israeli Defense Forces (IDF) where civilian access is restricted or limited (on foot or by vehicle). The historical northern distribution boundary of the *V. griseus* in Israel is unclear, but it is known that until the 1980s, there was a population of *V. griseus* in the Holon sand dunes (Stanner & Mendelssohn, 1987), and since then it has disappeared. Currently, the northern distribution boundary of the species is in the coastal plain sand dunes of Rishon LeZion.

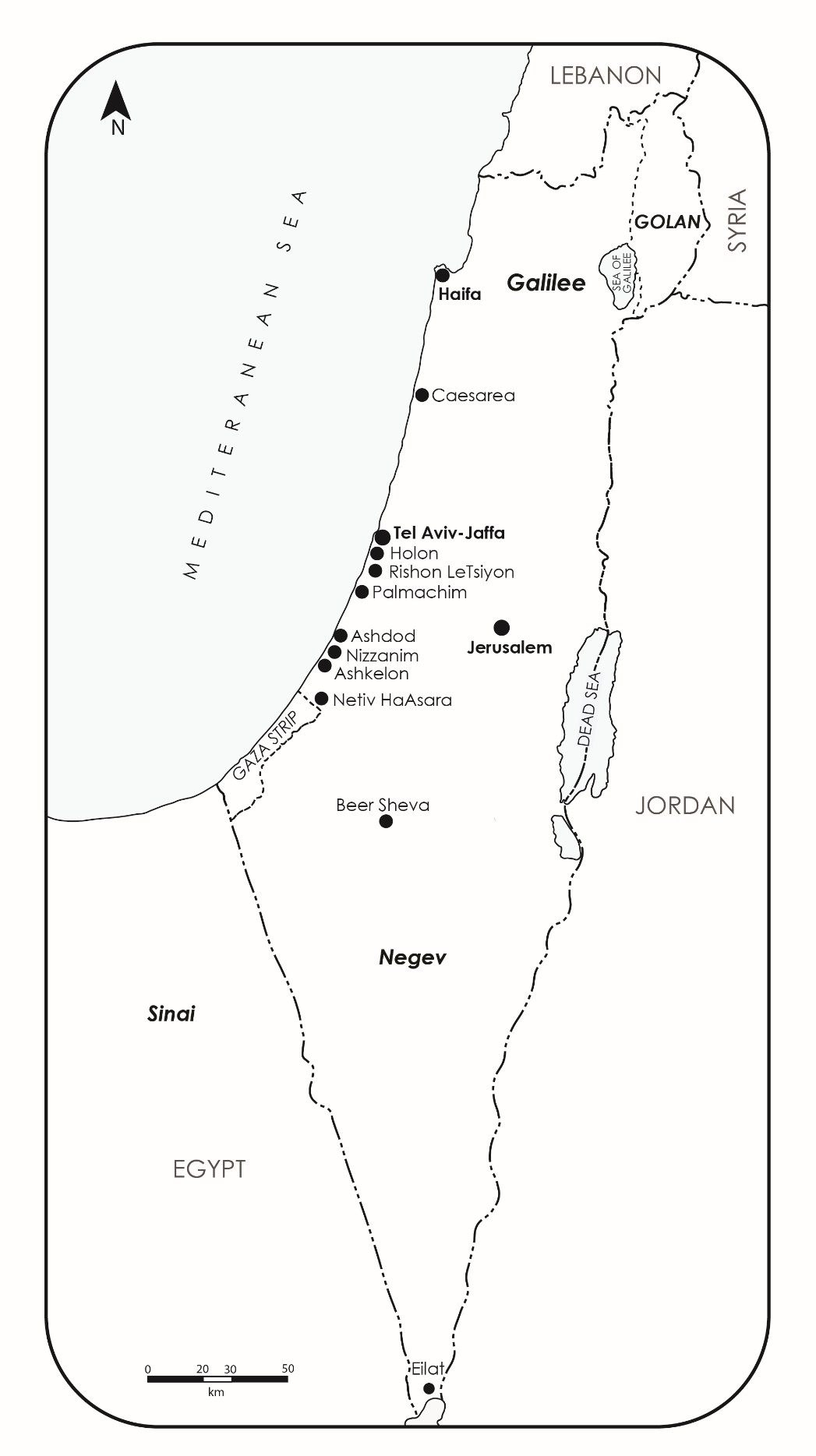
In each of the organism groups examined in the coastal plain and Western Negev sand dunes, it is noticeable that as the sand dunes undergo a process of fixation, generalist species gradually replace the characteristic psammophile species. In reptiles, for example, there has been a decrease in the frequency of sand-dwelling snake species, such as *Lytorhynchus diadema* and *Spalerosophis*, and an increase in the presence of generalist species, such as the *Eryx jaculus* and *Telescopus fallax* snakes. The reptile communities in the northern parts of the coastal sand dunes, such as the Caesarea sand dunes, provide a forecast for what may happen to the reptile communities in the southern coastal plain if the process of dune fixation continues and intensifies over time (Shacham, 2019).

**Photo 32:** Upper right: *Acanthodactylus scutellatus* (photo: Aviad Bar);left: *Acanthodactylus schreiberi syriacus* (photo: Aviad Bar); below: *Varanus griseus* (photo on the right: Boaz Shacham, on the left: Aviad Bar)

Appendix A: Map of Israel and its surroundings

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